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Papers: Original papers, furthering the objects of the society, are invited. They should be addressed to the Secretary, and their consideration by the Publications Committee will be facilitated if: (1) a brief but comprehensive outline or summary precedes or at least accompanies the completed paper; (2) manuscript and photographs are available in duplicate or triplicate; (3) original tracings or other drawings, from which copies are readily made, are available.

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AMERICAN CONCRETE INSTITUTE

Founded 1905; incorporated 1906 (National Association of Cement Users); charter amended 1913. (American Concrete Institute.)

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VOL. 2—NO. 10 JUNE 1931 (*Proceedings Vol. 27*)

JOURNAL
of the
AMERICAN CONCRETE INSTITUTE

News Letter

VOL. 27 TITLE PAGE AND INDEX PLUS 1931 DIRECTORY

This JOURNAL completes Vol. 27 of American Concrete Institute *Proceedings*—with a total of 1336 pages. These pages with the Abstracts (320 pages) are being indexed—in fact the indexing will probably be complete by the time this reaches you. Title page and index will then be separately printed and sent to all members and JOURNAL subscribers, ready for binding if your JOURNALS are to be bound. These extra pages for Vol. 27 will also include a complete list of members and committees and constitute the A. C. I. Directory for 1931.

The title, index and directory pages will be included in all bound volumes separately ordered from the Institute.

Members may buy the bound Volume 27 for $6.00—non-members $12.50. Members may have the *Proceedings* and *Abstracts* pages of their own JOURNALS bound with their title page and index for $2.10 if shipped direct to The Burkhardt Co., 545 W. Larned St., Detroit, Michigan, before Sept. 1, 1931. Be sure the package bears your name and address. Copy of letter of transmittal with remittance of $2.10 should be sent to the American Concrete Institute. After Sept. 1, 1931, individual sets will be bound for $2.60. *Do not send the* JOURNALS *to the Institute but direct to the binders.*

Members and regular subscribers may have bound volumes for next year (Vol. 28—Sept. 1931—June 1932) in addition to their monthly JOURNALS at a special *paid-in-advance* price of $3.00 if order and remittance are received by the Institute by Sept. 1, 1931.

Orders received before the first pages of Vol. 28 are printed in the next Journal (Sept. 1931) enable the Institute to print and store the extra forms each month. *Only paid in advance orders before Sept. 1, 1931*, can be taken at the $3.00 price.

*Fellows of the Institute**

4—Willis A. Slater

How much would concrete have lost in leadership, were it not for Professor Talbot's atelier at Urbana! There, for many years, Slater perfected his powers of analysis and matched wits and witticisms with Moore, Abrams, Wilson, Hollister, Richart and a host of other keen young research workers, instructors and graduate students. He shivered through wintry midnights on the early tests for actual stresses in concrete buildings. On other, more comfortable, midnights he began his immense output—I doubt if any one has ever exceeded it—of bulletins and papers and reports relating to the testing and design of concrete; all prepared with reckless expenditure of time, effort and thought; all written over and over until he was somehow satisfied to release them—and then finally entirely revised. His greatest concern was lest he "go off half-cocked." The Talbot tradition did not countenance loose thinking, nor partial data, nor careless composition.

Moving on to the Bureau of Standards, Slater frolicked away several more years in the same exacting sport of test and analysis. His union brain and body balked at the ceaseless grind of sixteen-hour days, but he drove them on, refused to rest even when headaches filled twenty hours out of the twenty-four. Attending conventions, he registered at hospitals rather than hotels, determined to cure his body without sacrificing precious time. And in the end, he won—spirit dominated flesh!

The World War brought a demand for ships, even ships of concrete, and Slater was placed in charge of their design. But he soon realized that new knowledge must precede design, if the ships were to float, and Research became his War, as it had been his Peace, task. He became director of the largest force, by far, ever concentrated upon concrete research up to that time. The results of that research constitute the principal (and very valuable) salvage from the concrete ship enterprise.

*A special order of distinction to which nominations are made from among his friends and associates in the Institute work by the author of a series of biographical sketches of which this is the fourth—Editor.

Following the war, other agencies demanded and secured his release from the Bureau, or his detail as a representative of the Bureau, for temporary service, as notably the Arch Dam Investigation, which carried him off to California for two happy, carefree years and resulted in more voluminous reports. After years as a common wrangler on the national Joint Committee on Specifications for Concrete and Reinforced Concrete, Slater has just recently become its Chairman—probably the highest honor that can come to a worker in this field. As Director of the Fritz Engineering Laboratory at Lehigh University, he is closely associated with many of the current major research projects, including the Institute's program of concrete column tests now under way at Lehigh and Illinois. He is chairman of the committee in charge of those tests, in fact. And also, as chairman of the Institute's Publications Committee, he is actively directing the increase of service to members through the JOURNALS. Each year brings added responsibility as he continues to demonstrate his exceptional ability-to-respond.

Sounds like a terribly earnest and lugubriously serious chap? Ah! but he's an inveterate gatherer and retailer of jokes and stories! I can "remember way back" to the time when his little daughter, weighing matters intuitively, used to deny herself all-day suckers in order to buy Daddy the latest Woolworth joke books. It was probably a wise choice for her and it never debased the quality of his offerings. Jokes, stories and long-winded, complicated design formulas (which other engineers have to whittle down) are Slater's principal and persistent relaxations. I am sorry to report that these weaknesses are becoming more pronounced with the years.

—ARTHUR R. LORD.

BOARD MEETS JUNE 27

THE Board of Direction of the Institute will meet in Chicago, Saturday, June 27, for consideration chiefly of the work of Finance, Advisory, Program and Publications committees.

The Finance Committee, Henry C. Turner, Chairman, will submit a budget for the fiscal year beginning July 1, next.

The Advisory Committee, Arthur R. Lord, Chairman, will report on new projects and on work in progress.

The Program Committee, P. H. Bates, Chairman, will report preliminary plans for the 28th Annual Convention to be held in Washington, D. C., March 1, 2, 3, and 4, 1932.

The Publications Committee, W. A. Slater, chairman, will probably recommend minor changes in physical makeup of the JOURNAL and some items of policy with respect to diversification of subject matter, effective with Vol. 28, beginning September next.

TECHNICAL COMMITTEES

Institute committee organization is a matter of annual review. Committees which have shown some progress on assigned tasks are in general being reappointed. A few changes are being made to meet the need only for active workers. The complete committee organization as of the close of the Institute's fiscal year (June 30) will be published in the 1931 Directory which will be issued to members next month with Title page and index of Vol. 27, which is completed with the June JOURNAL.

A. C. I. MEMBERS

DUFF A. ABRAMS

President American Concrete Institute, has resigned as Director of Research, International Cement Corp., and will organize his own research laboratory in New York for studies and consultation on design and control of concrete and other materials of construction and for development work in cement, aggregates and construction equipment. His work as Professor in Charge, Structural Materials Research Laboratory, Lewis Institute, and later when in charge of the research work of the Portland Cement Association, put him in the front rank of authority on cement and concrete. (See "Fellows of the Institute—1—Duff A. Abrams" by Arthur R. Lord, in these pages February 1931).

EDWARD D. BOYER

Past President American Concrete Institute—"Uncle Ed" to a host of friends—has left his post as technical service manager, Universal Atlas Cement Co., New York office, under the 70-year retirement rule of the United States Steel Corporation of which the Universal Atlas company is a subsidiary. He was born 73 years ago at Catasauqua, in the famous cement-producing Lehigh Valley, not far from the first American plant (1872) at Coplay; entered the cement business in 1888 as superintendent of a mill at Cementon, after specialization in chemistry at Muhlenberg College, Allentown and graduation (1877) from the Philadelphia College of Pharmacy. He joined the Atlas Portland Cement Co. in 1902 as assistant to the general superintendent of the Northampton plant and went to the general offices of the company in New York in 1914 as technical department manager. He is senior in service on this Institute's Board of Direction (also see "Fellows of the Institute—3—Edward D. Boyer" by Arthur R. Lord in these pages last month). He is a member of the Engineers', New York City and Westchester Hills Golf Clubs and lives at 55 East 10th Street, New York City. Still forward looking and defiant he insists "I was retired on the pension plan of the Steel Corporation—not because I wanted to retire." He will establish himself in consulting work on cement and concrete problems.

GEORGE S. BARTLETT

Special representative, Universal Atlas Cement Co., becomes assistant to the chairman of the board of the Portland Cement Association.

"Colonel" Bartlett has been closely identified for 20 years with the good roads movement, a pioneer in the introduction and promotion of concrete for highway and street paving; an important figure in the activities of the Portland Cement Association, with long experience and wide acquaintance in the cement and related industries. He was associated with several of the earlier cement companies in an executive capacity and for the last 16 years was with the Universal and more recently the Universal Atlas Cement Co. He was retired recently under the 70-year retirement rule of the United States Steel Corporation, of which the Universal Atlas Company is a subsidiary.

E. K. BORCHARD

succeeds Edward D. Boyer, retired (see above) as technical service manager of the New York office of Universal Atlas Cement Co. Mr. Borchard was technical service engineer for the company, having joined the Atlas

organization in 1917. In 1918, Mr. Borchard, in the service of the United States Shipping Board, was identified with concrete ship and barge construction.

NEW MEMBERS

EIGHTEEN applicants for membership in April have been approved by the Board of Direction as follows:

Annable, B. A., 145 State St., Springfield, Mass.

Arango, Enrico E., Arango and Lyon, Architects, 27 Central Ave., Panama City, Panama, C. Z.

Binder, R. W., 112 South Berendo St., Los Angeles, Calif.

Beckwith, G. L., 103 S. Rosanna St., Gilroy, Calif.

Brooks, Robert M., 178 Washington Ave., Bellville, N. J.

Dewey Portland Cement Co., 315 Union Bank Bldg., Davenport, Ia. (K. P. Ferrell)

Gain, Elmer W., 820 Baugh Ave., East St. Louis, Ill.

Goodman, Hal W., Box 347, Portsmouth, Ohio.

Grasselli Chemical Co., Inc., The, Guardian Bldg., Cleveland, Ohio. (R. F. Remler)

Guaranteed Concrete Co., 210 Builders Exchange, St. Paul, Minn. (A. R. Shiely, V. P.)

Iowa Concrete Crib & Silo Co., 820 S. W. Ninth St., Des Moines, Ia. (H. E. Kilmer, Gen. Mgr.)

Josephs, Arthur C., 320 E. 42nd St. New York, N. Y.

Keesee, Gerald B., P. O. Box 118, Brownwood, Texas.

Kerr, George W., State Highway Dept., 307 Trust Bldg., Newark, Ohio.

North Shore Cement Burial Vault Co., 2503 Buchanan Rd., Kenosha, Wis. (Hubert McQuestion)

Osler, Richard H., The Cement Marketing Co., Portland House, Tothill St., Westminster, London, England.

Ready Mixed Concrete Co., Quincy Ave., Knoxville, Tenn. (John L. Humberd, Pres.)

Twining, F. E., P. O. Box 1320, Fresno, Calif.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

A. V. Hutchinson, Secretary, American Society of Heating and Ventilating Engineers, extends to members of this Institute a cordial invitation to attend the semi-annual meeting at the New Ocean House, Swampscott, Mass., June 22-25.

BY-LAWS AMENDED

THE membership of the Institute has approved by a vote of 651 yes to 17 no an amendment to the By-Laws which disqualifies for membership on the Nominating Committee all Board members except Past Presidents.

The JOURNAL for Dec. 1930, (*News Letter*, p. 8) conveyed to Institute members a petition for the amendment of Section 3 of Article II. Following is the first paragraph of Sec. 3, Art. II, with the proposed additional sentence in italic:

> Section 3—There shall be a Committee of five members on nomination of officers elected by letter ballot of the members of the Institute which is to be canvassed by the Board of Direction at least six months prior to the annual convention. *The President, Vice-Presidents, Secretary, Treasurer and the Directors from the six geographical districts shall be ineligible for membership on this Committee.*

The proposed amendment was approved by a two thirds vote of the Convention, Feb. 26, 1931, and submitted to Letter Ballot of the membership as required in the By-Laws, Article VI. Of the 677 ballots returned nine were blank (signed but indicating no "yes" or "no" vote); 17 voted "no" and 651 voted "yes."

Papers and Reports—In this Issue

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Concreting the Calderwood Tunnel*

BY W. R. JOHNSON†

THE PROJECT

The Calderwood hydro-electric-development, one of the projects of the Aluminium Company of America, is on the Little Tennessee river, approximately a mile above Calderwood, Tennessee.

The development consists of a 230-ft. thin-section-arch overflow dam, with a 40-ft. gravity dam several hundred feet below, built to form a pool to cushion the overflow from the main dam; a 26-ft. pressure tunnel 2400 ft. long and the power house. Two 56,000 h. p. turbines are installed to operate under a head of 213 ft. Fig. 1 shows the general layout of the development.

As this report deals primarily with the concreting of the tunnel only a brief description will be given of the operations leading up to this work.

The entire length of the tunnel including penstocks is approximately 2400 ft. It is circular for the first 219 ft. from the intake, with a diameter of 26 ft. 6 in. inside the 12-in. concrete lining. The first 131 ft. of this section is level and the remaining 88 ft. slopes downward at an angle of 51 deg. with the horizontal. The next section, 1727 ft. 6 in. slopes downward on a 2 per cent grade. This section is 26 ft. wide, with 11-ft. vertical side walls and a semi-circular crown of 13 ft. radius. The last 400 ft. branches out into three 16-ft. steel penstocks which slope steeply downward into the power house.

The entire tunnel was driven or excavated from an adit at the lower end of the tunnel. This adit is not a part of the permanent

*Presented by title (in author's absence) at 27th Annual Convention, Milwaukee, Feb. 24-26, 1931.

†Concrete Technician, Calderwood Development, of the Aluminum Company of America.

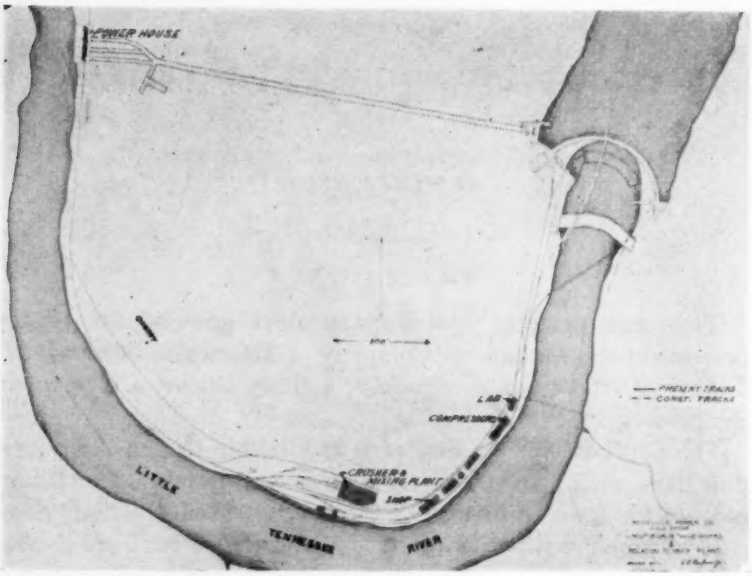


FIG. 1—GENERAL LAYOUT CALDERWOOD HYDRO-ELECTRIC DEVELOPMENT ON LITTLE TENNESSEE RIVER

tunnel and intercepts penstock No. 3 at the level of the main tunnel.

An 11 by 11-ft. heading was driven the entire length of the tunnel and later enlarged to full size by drilling and shooting. During the driving of the heading the muck was handled by an electric mucking machine (Fig. 4) and loaded into 2-ft. gage cars handled by storage battery locomotives. In the enlarging operations the muck was loaded into standard gage 6-yd. cars by a 1¼-yd. air shovel and removed by a gasoline-electric locomotive. The muck was later sent to the crushing plant and made into concrete aggregate, for use in the tunnel or dam as required. The dimensions of the tunnel are shown on Fig. 1 and 5.

All concrete was mixed at a plant located about ½ mile from the tunnel adit and transported to the tunnel in 2-cu. yd. sloping side buckets loaded on flat cars pulled by 20 ton "dinky" steam locomotives. The mixing plant was equipped with a 2-cu. yd. Smith tilting (56S) mixer.

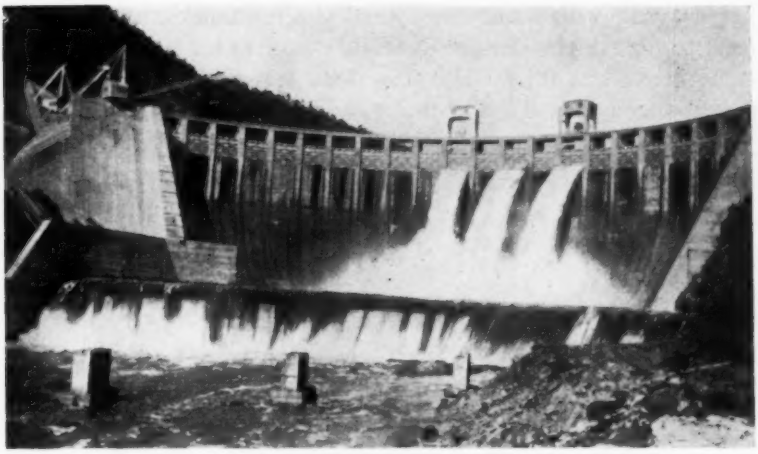


FIG. 2—CALDERWOOD DAM

CONCRETE MATERIALS AND TESTS

In addition to that obtained from excavations for the dam and tunnel, the aggregate used was taken from a quarry about 300 yds. from the crusher and mixer plant. This material was hard, dense arkose and made excellent aggregate. The coarse aggregate was graded from ¾ in. to 3 in. while the fine aggregate was manufactured and produced from the same material and graded from 0 to No. 4. Previous tests and experiments had shown that the elimination of material under ¾ in. in the coarse aggregate prevented raveling and separation of sizes in the bins, thus giving a more uniform product when but one bin was used for coarse aggregate.

The concrete for the entire Calderwood project was designed to produce a compressive strength of 3000 lb. per sq. in. at 28 days when tested as an 8 by 16-in. cylinder. All aggregate larger than 2 in. was removed from the concrete by hand picking at the time the specimens were molded. It was found, however, that a number of the cylinders could not be broken in the 200,000-lb. Olsen hydraulic testing machine, as the strength went beyond the capacity of the machine (4000 lbs. per sq. in. for an 8 by 16-in. cylinder). These strengths were being obtained from concrete placed in the main dam and with a cement content of 4½ bags

per cu. yd., which was considered the minimum that could be used to obtain the desired durability and water tightness in the structure of this type. The size of the test specimens was therefore reduced to a 6 by 12-in. cylinder with all aggregate larger

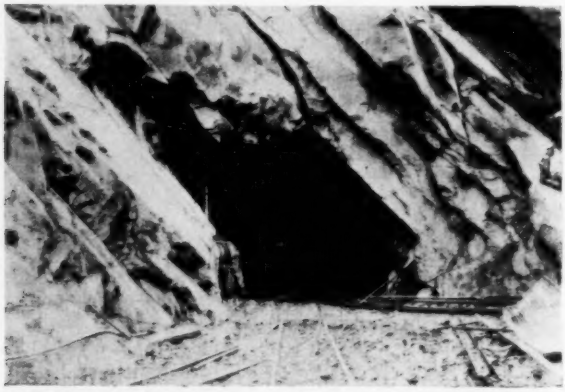


FIG. 3—TUNNEL CONSTRUCTION ADIT
FIG. 4—MUCKING MACHINE IN 11 BY 11 FT. HEADING

than 1½ in. removed from the concrete. Comparative tests showed that the 6 by 12-in. specimens gave strengths equal to 108 per cent of the strengths obtained from 8 by 16-in. specimens molded from the same batch. The average water-cement ratio

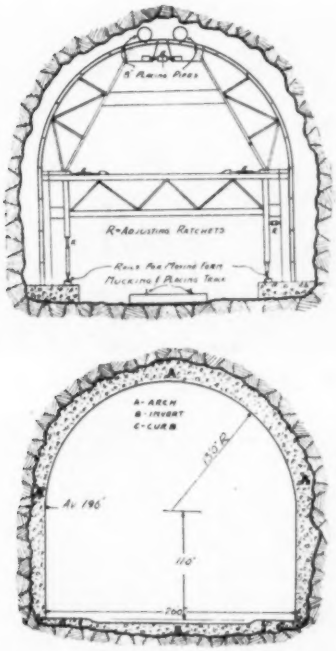
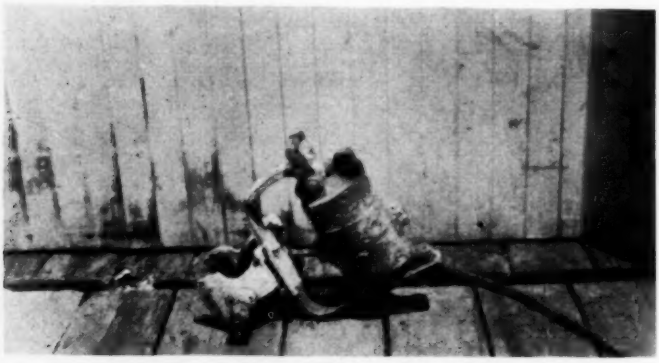


FIG. 5—MAIN TUNNEL SECTIONS, UPPER SECTION SHOWING STEEL FORMS

used for the concrete placed in the main dam was .95 (7.0 gal.), which gave an average strength of 4000 lb. per sq. in. at 28 days. For the tunnel concrete this water ratio was reduced slightly (.90) in order to give a greater factor of safety upon removal of forms 11 to 15 hours after placing. Preliminary tests made with 8 by 16-in. cylinders broken at the age of 14 hours indicated that a water-cement ratio of .90 (6¾ gal.) would give sufficient strength to move the 30-ft. Blaw Knox steel form without danger of any caving in the arch section. In actual practice the form was successfully moved several times, 11 hours after placing the concrete.

PLACING OPERATIONS

The total concrete placed in the entire tunnel, which included intake, main tunnel, and surge shaft, was 28,000 cu. yd. About 85 per cent of this yardage was placed with pneumatic placers.



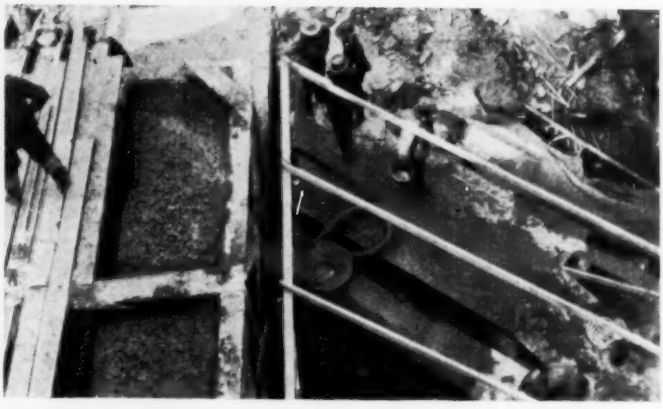


FIG. 6—ELECTRIC VIBRATOR
FIG. 7—CONCRETE HOPPERS AND PNEUMATIC PLACERS

In general, three separate placing operations were used in the main tunnel. In order of procedure they were: curb, arch, and invert. The concrete sections of the 16-ft. circular penstocks were placed in two operations, bottom segment and main segment, or sides and top. Wooden forms, built in place, were used. The incline section of the main tunnel, which was circular, having a diameter of 26 ft. 6 in., was placed in the same manner as the penstocks. The surge shaft, which had a diameter of 18 ft. and an angle of 51 deg. with the horizontal, was placed in one operation, using collapsible, movable, wooden forms.

In the concreting of the main tunnel flat cars of standard gauge, mounting specially designed hoppers, were used for hauling material from the construction adit or portal into the tunnel. Each car was equipped with four hoppers (Fig. 7), each hopper having a capacity of two cubic yards and arranged so that concrete could be dumped simultaneously from both sides of the car into the curb forms or pneumatic guns, as the case might be.

The placing of the concrete in the main section was started at the foot of the riser, upstream, and progressed down hill on a 2 per cent grade. The curb (Fig. 5) for the entire length of the tunnel was placed first and later used as a foundation for moving and setting the 30-ft. collapsible Blaw Knox steel form used in concreting the arch section. The invert, or tunnel floor, was placed with one pneumatic gun, the operations following 60 to 90 ft. behind the arch placement.

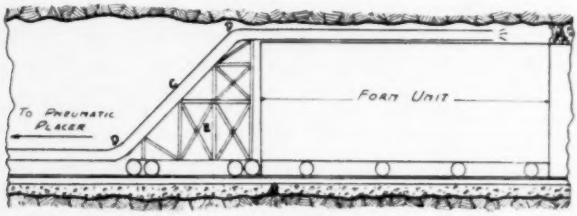
Main Tunnel

Curb—The foundation or bottom was thoroughly cleaned of all muck and washed with a hose. The hopper cars, pulled by a gas electric locomotive, then brought the concrete from the tunnel portal to the forms where it was allowed to flow by gravity from the bottom gate of the hopper through a short, movable chute into the forms where it was spaded into place. Two sections of curb, one on each side of the tunnel, were placed simultaneously.

Arch—The average cycle of operations for concreting of a 30-ft. section of arch was as follows:

1. Moving and setting forms, 3 hours.
2. Placing concrete, 6 hours.
3. Setting and hardening of concrete, 15 hours.

This schedule was adhered to as closely as possible. Delays of different types, such as breakdowns of pneumatic guns, derailment of hopper cars, placing pipe troubles, etc., prevented placing every day. The average loss of time due to these troubles, however, was only about one day every two weeks. The first section of arch placed required 36 hours. Within 10 days this time had been cut down to 6 hours, which was the average time required for placing, although several sections were placed in less than 5 hours.



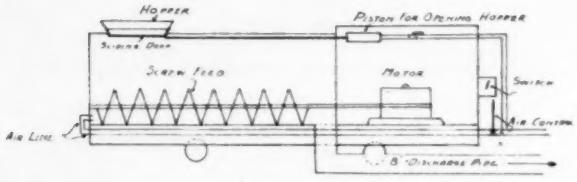


FIG. 8—(UPPER) PIPE SECTION SHOWING PLACING METHOD

LEGEND

A—PREVIOUS POUR
B—COMPLETED CURB
C—8 IN. PLACING PIPE
D—45 DEGREE BENDS
E—PIPE SUPPORT ON STANDARD FLAT CAR

(LOWER) RANSOME PNEUMATIC PLACER

Fig. 8 shows the set-up used for placing concrete in the arch. The procedure in filling the forms was as follows:

The concrete was brought from the construction adit to the form in hopper cars drawn by a gas-electric locomotive. From the hopper it was fed by gravity through the gates at the bottom into the two pneumatic concrete placers, one on each side of the car. These placers had a capacity of 14 cu. ft., and were of the horizontal type. The placers operated as follows:

The concrete entered the guns (Fig. 8) through a sliding door controlled by compressed air and at the back end and on top of the cylindrical barrel. From here it was forced by a screw feed, operated intermittently, away from the sliding door toward the front end of the barrel until the gun was fully charged. The sliding door was then closed and the screw feed and the air turned on. This action forced the concrete into the 8-in. discharge pipe through which it was forced by the air to its final place of deposit in the forms.

Attached to the forms with clamps were two electric tampers (Fig. 6), one on either side. These were run intermittently during the placing operations and were, no doubt, responsible to some extent for the smooth surface obtained.

In some of the first placements difficulty was experienced with honeycomb occurring in the lower corners next to the previous day's pour. This was caused by segregation in the delivery pipe during the blowing operation. The separation was such that the coarse aggregate was always delivered ahead of the mortar to an extent depending on the plasticity or workability of the mix.

To overcome this difficulty a batch of stiff mortar was first "shot" into each of the lower corners. This was followed by concrete in which the amount of coarse aggregate had been considerably reduced. About the first 15 per cent of the form was placed in this manner, after which the stone content of the concrete was brought back to normal. Very little honeycomb occurred after this method was adopted.

The two major problems encountered in the concreting operations were placing pipe breakdowns and improper consistency of the concrete. The second condition was in most cases the result of the first. The majority of the pipe troubles occurred at the elbows or bends, and the replacements of these sections occurred frequently. The first bends used were made of extra-heavy steel pipe. At the upper elbow, next to the form (Fig. 8), this type of bend was not good for placing more than 150 cu. yds. of concrete. The lower bends, next to the gun, lasted considerably longer. The second type tried was a Hagen-White iron elbow with reversible back. This elbow was a great deal more successful, and, by reversing the back, was good for placing approximately 600 cu. yds. of concrete, after which the backs were replaced.

Trouble was also encountered with pipe flanges, three different types being used before finding one that was satisfactory. These flanges and the order in which they were tried follow: cast-iron, ferro-steel, and steel.

The ends of the discharge pipes were equipped with 22½ deg. extra-heavy steel bends. Frequent patching was necessary to keep these in shape. Some 45 deg. bends were tried and also some

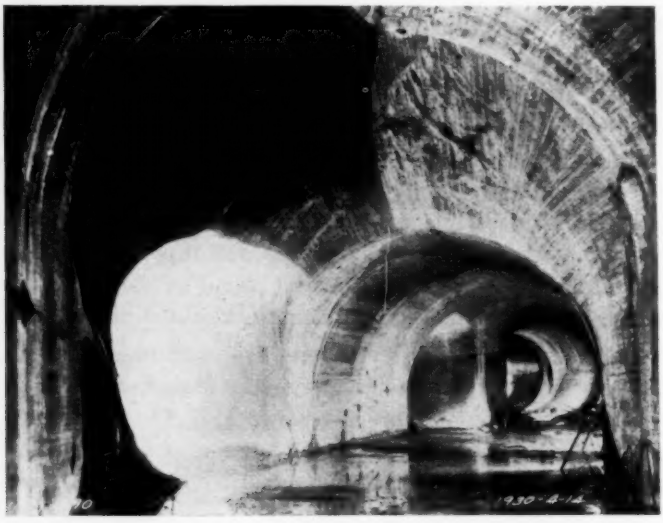


FIG. 9—MANIFOLD SECTION OF TUNNEL SHOWING ENTRANCES TO PENSTOCKS AND SURGE SHAFTS

straight sections. The most satisfactory position for the ends of the discharge pipe at the beginning of a pour was 5 to 6 ft. from the back of the bulkhead. After the form was one third to one half full, however, the position of the end of the discharge pipe or whether it was equipped with a bend or was straight did not seem to matter, equally good results being obtained with the end of the pipe placed 20 ft. from the bulkhead.

The consistency or workability of the concrete was one of the controlling factors in the placing operations, and great care was exercised to keep it correct in order to avoid delays in placing, as well as to prevent honeycomb in the finished job.

For proper placing, it was found that the concrete should be neither too wet nor too dry. A mix that was too wet would segregate badly during placing operations, while one that was too dry could be removed from the hoppers only with great difficulty. The ideal mix for pneumatic placing with materials used on this job was one that gave a slump of 4 to 5 in. with approximately a 1:2:3 mix and which did not segregate upon

being removed from the hopper cars. A mix of this type would "shoot" with great ease and segregate but little in the form.

As short a delay as 15 minutes at the placers during concreting operations would be sufficient to upset the entire cycle of operations, so that the ultimate delay might easily total an hour or an hour and a half before all of the setting concrete could be removed from the loaded hopper cars and buckets. Having no means with which to keep the concrete in the buckets or hoppers agitated when allowed to stand for 30 minutes or more, great difficulty was experienced in removing it, especially from the hoppers, after this time. To prevent delays of this type as much as possible, the inspector kept in constant touch with the mixer plant and the transfer operations at the tunnel entrance. No concrete was transferred from the buckets to the hopper cars if a breakdown occurred, and if the delay amounted to more than 30 minutes, the material was sent to the dam where it could be easily placed in the open forms by means of the electric tampers used in this work.

Invert—After thoroughly cleaning the invert, or bottom, of all muck and dirt, and washing with a hose, the concrete was brought in a hopper car to the placer on the right hand side of the tunnel. From here it was blown through an 8-in. pipe, 100 to 125 ft. long, into the invert form which was a great deal like a small section of pavement slab. A small wooden bulkhead, or stop, was used at the discharge end of the placing pipe to prevent the concrete from scattering unduly. From this point the material was shoveled into place and brought to grade by means of a screed, after which the surface was finished by means of a wooden float.

While this method of placing produced some surface laitance, due to the wet mix necessarily used with the pneumatic placers, it was decidedly the most economical process. The set-up was the same as that used in placing the arch section with the exception of one or two small changes in pipe connections. The work was done at night, thus not interfering in any way with the placing of the arch section.

With the small temperature changes encountered in a tunnel of this type, with no alternate freezing and thawing, and with

practically no abrasive or wearing action due to the slowly moving water, the writer does not believe that scaling on account of this laitance will be particularly detrimental to the concrete lining.

FIG. 10—MAIN TUNNEL

Penstocks and Riser

The same general procedure was used for concreting the riser and penstocks as was used in the main tunnel, with the exception that the forms were wood, built in place. Due to the small size of the penstocks, but one placer was used. This made it necessary to shift the end of the delivery pipe from one side to the other. Vibrators were not used, the concrete being booted and tramped into place.

Surge Shaft

The two-yard buckets of concrete were removed from the train and dumped into a hopper mounted on a platform at the foot of the mountain in which the surge chamber and shaft were located. From here it flowed by gravity into a second hopper mounted on a specially built car which was then pulled by cable, powered from the unloading derrick, approximately 250 ft. up a steeply inclined narrow gauge track to a third hopper on the mountain side. After being dumped into this hopper, the concrete flowed through a short chute into an upright pneumatic placer of somewhat different type from those used in the tunnel. This placer then "shot" the material through an 8-in. pipe, approximately 200 ft. long, into a fourth hopper at the top of the construction adit of the surge shaft on the mountain side. The concrete then flowed by gravity from this hopper through a second 8-in. pipe and into the surge shaft forms, its final place of deposit.

The somewhat complicated method described above was adopted in order to utilize a part of the same set-up that had been used previously in placing the power house protection walls.

STRENGTH TESTS

In Fig. 11 are plotted the 28 day strengths obtained from the concrete placed in the main tunnel section. The curves show that the average strength was approximately 4000 lb. per sq. in. The average mix was 1:2:3 by dry loose volumes, and the average cement content 1.5 bbls. (6 bags) per cu. yd. of concrete. The surge shaft and penstock concrete gave approximately the same result.

GROUTING

Several months after the completion of the concreting operations the entire tunnel was grouted in order to give it additional strength and water tightness. In the roof of the arch section of the main tunnel, where the cavities were comparatively large, a rich mortar was used for this purpose, while in the other sections a neat cement mixture was used. The grout, or mortar, was forced into place through a hose by means of a grout pump or mixer, capable of exerting pressures up to 100 lb. per sq. in. Holes drilled at regular intervals through the concrete lining in the roof of the tunnel provided the necessary connections for the hose for forcing the grout into place (Fig. 10).

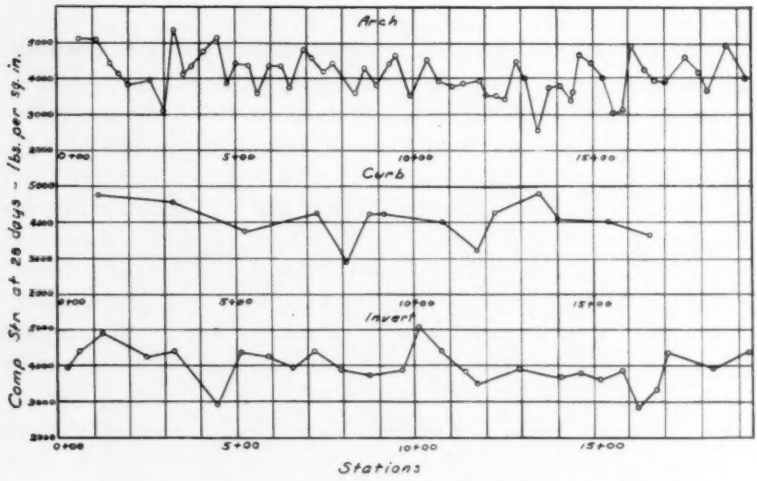


FIG. 11—TUNNEL CONCRETE STRENGTHS AT 28 DAYS

CONCLUSION

The success of a concreting operation using the methods described is dependent in a large degree on the proper co-ordination and co-operation of the different units involved. Without this co-operation costly delays may occur to upset the entire cycle of operations, thus running the costs up appreciably.

Acknowledgment is therefore made to those in responsible charge of this work for their co-operation with the writer in obtaining the results they did. The writer also wishes to thank in particular R. F. Taylor and E. B. Rayburn who, in their capacity as inspectors, worked tirelessly to obtain a high quality of concrete and its proper placement in the finished job.

Calderwood Development was designed under the direction of James W. Rickey, Chief Hydraulic Engineer of Aluminum Company of America, by James P. Growdon, Principal Assistant Hydraulic Engineer. I. G. Calderwood was the General Superintendent of Construction, under whose direction the tunnel was built.

Readers are referred to the JOURNAL *for December, 1931, (Vol. 28) for further discussion which may develop. Such discussion should reach the Secretary by Nov. 1, 1931.*

Field Practices in Using Concrete Aggregates In Multiple Sizes*

BY T. C. THEE†

The division of Management of the United States Bureau of Public Roads is entering its eighth year of study of highway production problems and of the methods of eliminating waste in the construction of highways.

Studies of construction methods and equipment are conducted in all parts of the United States and include nearly all types of highway construction projects, including portland cement concrete, asphaltic concrete, sheet and sand asphalt, bituminous macadam and brick pavement. The grading work includes power shovels, elevating graders, wheeler and fresno outfits. Miscellaneous studies include drilling and blasting operations, aggregate crushing plants, local pit plants, etc.

Field investigational work is in constant operation to study possible changes that can be recommended further to reduce cost without sacrifice of quality. We hold quality of work as paramount. In these attempts to reduce costs and at the same time maintain quality we feel that we have made steady progress. The studies are cooperative, in which the Bureau, State and County highway officials are all concerned.

Coarse aggregate in separated sizes is now being used by the states to some extent where the maximum size is 1½-in. or more, or where a foreign aggregate is brought in to be incorporated in the mix to meet grading specifications.

Three states, California, Washington and New Jersey, require coarse aggregate to be batched in two sizes under all conditions. North Carolina, Louisiana, Georgia, Arkansas, Maine and Vermont require two-way batching under certain conditions.

*Presented at the 27th Annual Convention, Milwaukee, Feb. 24-26, 1931, with discussions by Messrs. Hambrecht and Langley, which follow in these pages.

†Assistant Highway Engineer, Division of Management, Bureau of Public Roads.

A few other states have used, or are using, two-way batching on special projects. Wisconsin tried three sizes of coarse aggregate on special projects last year, and on one project four sizes. No state requires a three-way split in batching. One state tried three sizes but has returned to the use of two sizes of coarse aggregate.

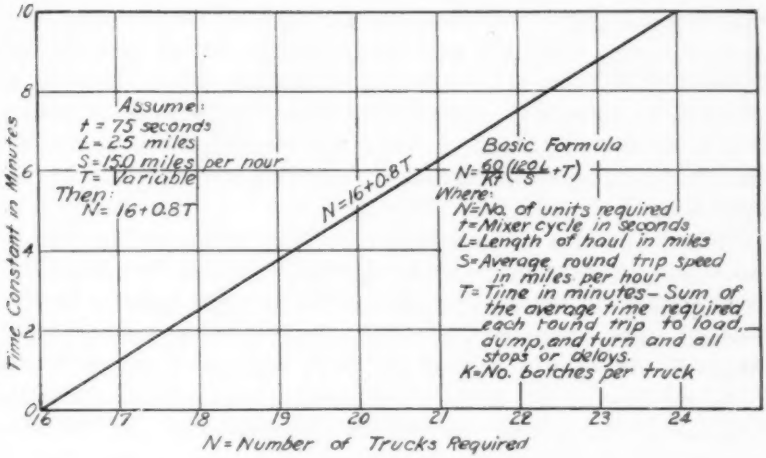
This separation of sizes is to eliminate as much as possible the segregation that takes place in car delivery and in stock piling the material, so as to maintain uniform gradation of the coarse aggregates and to reduce the batch-to-batch variation.

In using separated sizes of coarse aggregate the states specify the grading for each size. The point where the separation should be made is stated in the range of size. For example, No. 1 aggregate would be from 2½ in. to 1 in. and No. 2 aggregate from 1 in. to ¼-in. The material is delivered by rail in these two sizes. Two separate stock piles are maintained for these and one stock pile for the sand. Modern three compartment bins should be used and the three aggregates weighed separately. Moisture adjustments are made on the separate sizes and on the sand. The percentage of each size of coarse aggregate is adjusted to meet specifications and to obtain the least void content in relation to the best gradation and economy of aggregate production.

From the standpoint of batcher operation there is but little objection to two-size batching of the coarse aggregate where three-compartment bins are available. The real difficulties come in finding room for three instead of two stock piles, and in getting cars spotted correctly, as well as having each shipment carry the proper amounts of each size and the proper gradation.

Delays sometimes occur also at the beginning of a job or even in the progress of a job, due to variations at the producer's plant in the gradation of each size of the specified aggregates. As a consequence, the mix is often changed and this again may result in delays to the contractor because of the difficulty in ordering accurately the proper amount of each size.

These are all matters of real importance which cannot be forecast with precision. They do add to the difficulties with which the contractor has to contend and increase the opportunities for delay.


Time Constant in Minutes
N = Number of Trucks Required
Assume:
t = 75 seconds
L = 2.5 miles
S = 15.0 miles per hour
T = Variable
Then:
N = 16 + 0.8T
N = 16 + 0.8T
Basic Formula
N = 60/Kt (120L/S + T)
Where:
N = No. of units required
t = Mixer cycle in seconds
L = Length of haul in miles
S = Average round trip speed in miles per hour
T = Time in minutes – Sum of the average time required each round trip to load, dump, and turn and all stops or delays.
K = No. batches per truck

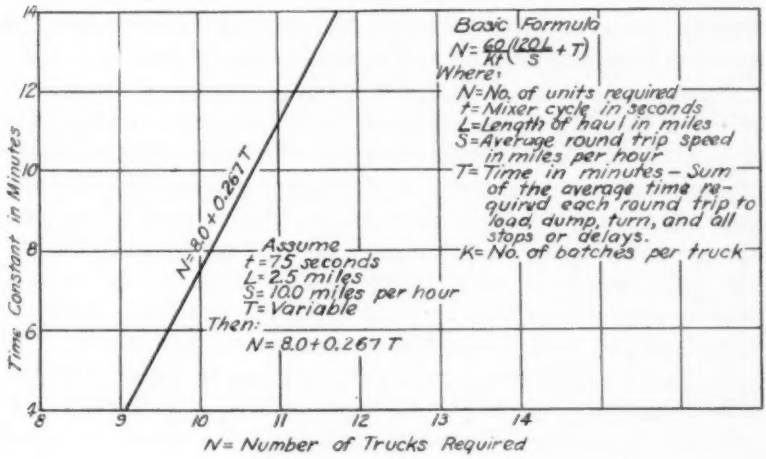

Time Constant in Minutes
N = Number of Trucks Required
Basic Formula
N = 60/Kt (120L/S + T)
Where:
N = No. of units required
t = Mixer cycle in seconds
L = Length of haul in miles
S = Average round trip speed in miles per hour
T = Time in minutes – Sum of the average time required each round trip to load, dump, turn, and all stops or delays.
K = No. of batches per truck
N = 8.0 + 0.267T
Assume
t = 75 seconds
L = 2.5 miles
S = 10.0 miles per hour
T = Variable
Then:
N = 8.0 + 0.267 T

FIG. 1—EFFECT OF TIME CONSTANT ON THE NUMBER OF ONE BATCH TRUCKS REQUIRED ON CONCRETE PAVING

FIG. 2—EFFECT OF TIME CONSTANT ON THE NUMBER OF THREE BATCH TRUCKS REQUIRED ON CONCRETE PAVING

With the modern three-compartment batcher the time required for handling the three-way batch (two sizes of coarse aggregate and one of sand) is very little greater than for the two-way (one size of coarse aggregate and one of sand). Either type can be loaded while the truck is driving in, and the batch dropped in from 10 to 15 seconds, which is the length of the necessary stop for a one-batch truck. Even a three-batch truck is readily loaded with the three batches of sand and two sizes of stone or gravel in 75 seconds.

Where two bins are used the truck "time constant" is of course increased by the time required to get in position at the second bin and receive the batch or batches of the material handled by the second bin. A second bin reduces the crane operating time, through time lost in moving the crane from stock pile to stock pile and bin to bin. If the yard layout is poor, the time lost in moving the crane and the truck "time constant" may be considerable. This loss may be as much as three minutes for a three-batch truck, necessitating one or two extra trucks on the average job. This item alone is costly. Figs. 1 and 2 show the effect of time constants on the number of trucks required.

Stock piling practice varies so greatly and the requirements imposed by the states are so different that really comparable data are few. Under average conditions, when loading from cars to bins the crane cycle seems to vary between 30 and 45 seconds, depending on the skill of the operator, the angle of swing, and the general working conditions. When the car is nearly empty the rate usually is considerably slower. The fastest rate is usually obtained in working from a full car to stock pile, when if the swing is short the cycle may be as low as 25 seconds. The rate of operation does not seem to be appreciably affected by the size of the crane. That is, of two cranes in equally good condition the larger may be expected to operate on about the same cycle as the smaller. This seems to hold good at least for sizes from ¾ to 1½ cu. yd.

The most efficient contractors are finding it difficult to unload cars, stock pile, and fill the bins during the day and have to resort to several hours operation of the crane at night.

On the basis of a 60-second mixing time, a 30-cu. ft. batch, averaging 45 batches per hour using five sacks of cement per

cu. yd. of concrete, and a workability factor b/b_o of 0.76, 63,900 pounds of sand and 114,300 pounds of gravel will supply the 27-E paver per hour or a total of about 60 cu. yd. of material per hour.

With a crane averaging a cubic yard of material per bucket with a 35-second cycle, approximately 90 cu. yd. of material would be handled by the crane per hour, with allowance for necessary delays. This means that under favorable conditions the crane can produce about 50 per cent more than the requirements of the mixer if the material is loaded directly from cars to bin. If the material has to be stock piled first, then the crane would have to operate unloading cars partly at night. If material is delivered by trucks either from a nearby commercial plant or a local plant, the crane can easily maintain the necessary supply within the regular hours.

On the basis of a 50-second mixing time with a 33-cu. ft. batch, the crane will have available approximately 18 per cent leeway to load from cars to bins direct. However, if the specifications are such that two bins must be used, using three sizes of coarse aggregate, two cranes will have to be employed.

Where three sizes of coarse aggregate are delivered to a job by rail and three-batch trucks are used, the requirement of three sizes of coarse aggregate will cost the state indirectly through the

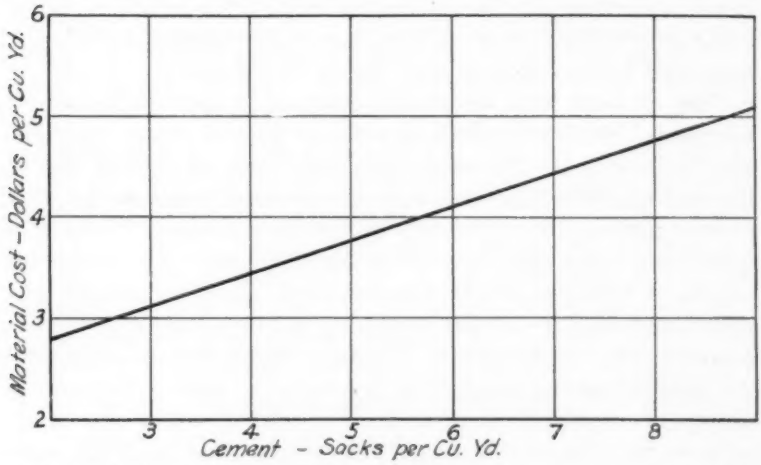


FIG. 3—EFFECT OF CEMENT CONTENT ON COST OF CONCRETE

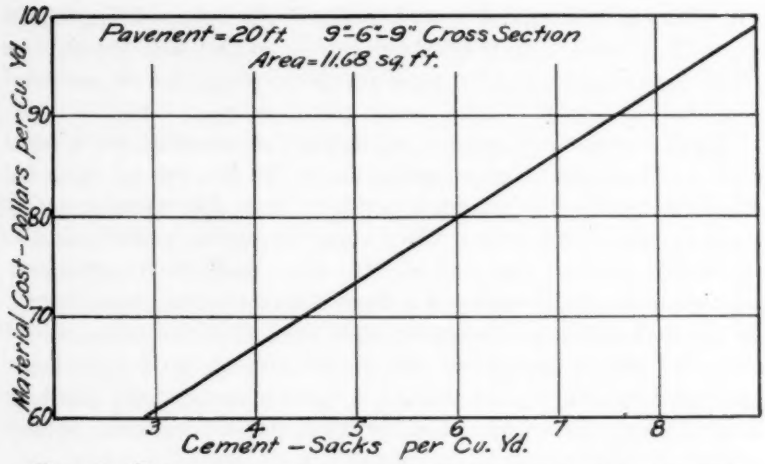


FIG. 4—EFFECT OF CEMENT CONTENT ON COST OF CONCRETE

contractor about $105 per day, or an average of $630 per mile, or 5.4 cents per sq. yd. of pavement. This is a cost equivalent of adding 0.78 sacks of cement to a 33-cu. ft. batch. Fig. 3 and 4 show the effect of cement content on the cost of pavement per cu. yd. and per sq. yd. respectively.

With a local or commercial plant delivering by trucks, the three sizes of coarse aggregate will cost approximately 1½ to 2 cents per square yard more than two sizes. No accurate average costs are available showing how much more three sizes of coarse aggregate cost to produce over one or two sizes.

Two projects were selected in Sheboygan county, Wisconsin, for special study of the use of multiple sizes of coarse aggregate and to investigate the effect of mixing time and batch size on the uniformity of ingredients of the concrete produced by 27-E pavers, and on the uniformity of resulting strength of concrete both for compression and transverse strength. The associated unit costs were also collected and studied. Before these two jobs were advertised to bidders careful laboratory experiments were conducted by the Wisconsin Highway Department to determine the desired grading and mix to use with the different sources of supply of aggregate materials. No discrimination was made between the different brands of cement available, although some difference existed.

On these two Wisconsin projects—S. A. P. 2916 and S. A. P. 2926—three sizes of coarse aggregate were specified with definite grading requirements. Five sacks of cement per cu. yd. of concrete as the minimum and six gal. of water per sack of cement as the maximum, were recommended so as to produce at least 650 lbs. per sq. in. transverse strength at 28 days.

The mixes on both jobs were designed for the minimum allowable cement content and maximum allowable water content. The workability of the concrete was maintained through the adjustment of the gravel and sand content employing the workability factor b/b_o as developed by Richart and Talbot. The method is shown graphically and the process of establishing the mix can be interpreted from the chart, Fig. 5. A workability factor b/b_o ratio of 0.76 seemed to work best on both jobs. The dashed line on the chart shows the mix developed on the basis of a b/b_o ratio value of 0.76.

The three sizes of aggregates were also recombined experimentally using different percentages of each size, in order to obtain as low a void content as possible without sacrifice of gradation in obtaining workable concrete.

The proportions of the various sizes as required by the specifications are as follows for S. A. P. 2926 (Sheboygan county, Wisc.).

No. 1	2½ in. to 1½ in.	30-35 per cent
No. 2	1½ in. to ¾ in.	45-50 per cent
No. 3	¾ in. to ¼ in.	15-25 per cent

No. 1 Coarse Aggregate, 2½ in.-1½ in.

	Per Cent
Retained on 3 in. circular opening	0
Retained on 2½ in. circular opening	0- 10
Retained on 1½ in. circular opening	90-100
Retained on 1¼ in. circular opening	100

No. 2 Coarse Aggregate, 1½ in.-¾ in.

	Per Cent
Retained on 1¾ in. circular opening	0
Retained on 1½ in. circular opening	0- 10
Retained on ¾ in. circular opening	90-100
Retained on ½ in. circular opening	100

No. 3 Coarse Aggregate, ¾ in.-¼ in.

	Per Cent
Retained on 1 in. circular opening	0
Retained on ¾ in. circular opening	0- 5
Retained on ¼ in. circular opening	95-100
Retained on No. 10 sieve	100

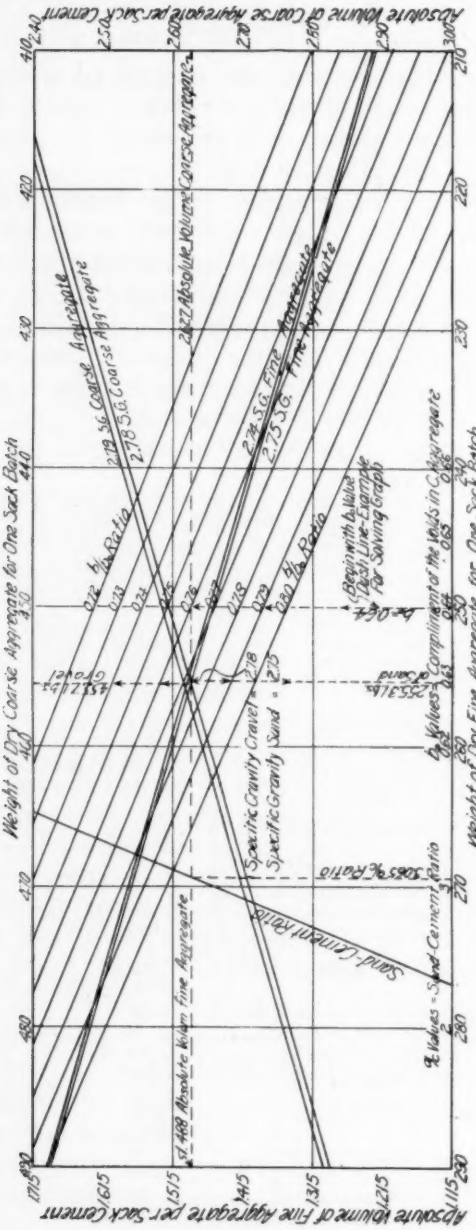

Absolute Volume of Coarse Aggregate per Sack Cement
Weight of Dry Coarse Aggregate for One Sack Batch
Weight of Dry Fine Aggregate for One Sack Batch
Absolute Volume of Fine Aggregate per Sack Cement
Sand-Cement Ratio
Specific Gravity Sand = 2.75
Specific Gravity Gravel = 2.78
Begin with Dotted Test Line Example for Solving Graph
Compilation of the Values in Colors
Values = Sand Cement Ratio

FIG. 5—GRAPH FOR AGGREGATE ADJUSTMENT IN MAINTAINING WORKABILITY WITH FIVE SACKS CEMENT PER CUBIC YARD OF CONCRETE AND 6 GALLONS OF WATER PER SACK OF CEMENT

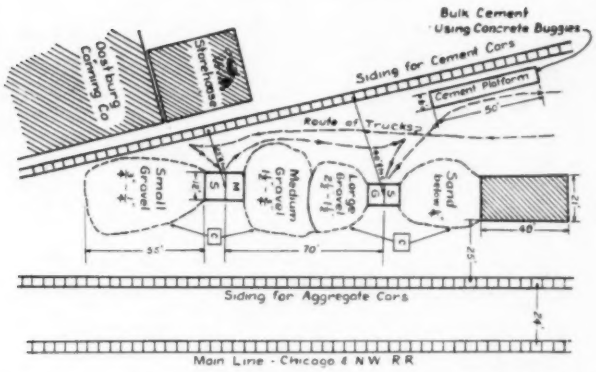


FIG. 6—PLANT LAYOUT, WISCONSIN S. A. P. 2916, SHEBOYGAN COUNTY—THREE SIZES OF COARSE AGGREGATE

Figs. 6 and 7 show the plant layout and set-up on Wisconsin S. A. P. 2916. It is obvious that a very crowded condition existed. Using three sizes of coarse aggregate made it very cumbersome. The plant was such that trucks lost on an average of two minutes over a typical set-up, resulting in the use of one and sometimes two trucks more than would normally be used; an extra crane was required; the material was delivered by rail.

FIG. 7—PLANT SET-UP, S. A. P. 2916, SHEBOYGAN COUNTY, WISCONSIN, USING THREE SIZES OF COARSE AGGREGATE AND ONE OF SAND; MATERIALS DELIVERED BY RAIL

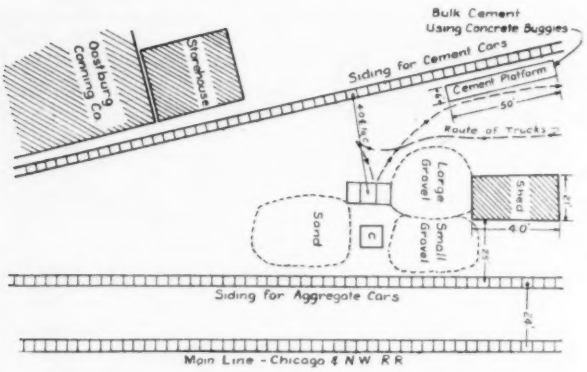


FIG. 8—SUGGESTED PLANT LAYOUT, WISCONSIN S. A. P. 2916, SHEBOYGAN COUNTY—TWO SIZES OF COARSE AGGREGATE

Fig. 8 shows the same plant site but with equipment and stock piles planned for handling two sizes of coarse aggregate. This set-up would not result in any greater cost than for only one size of coarse aggregate.

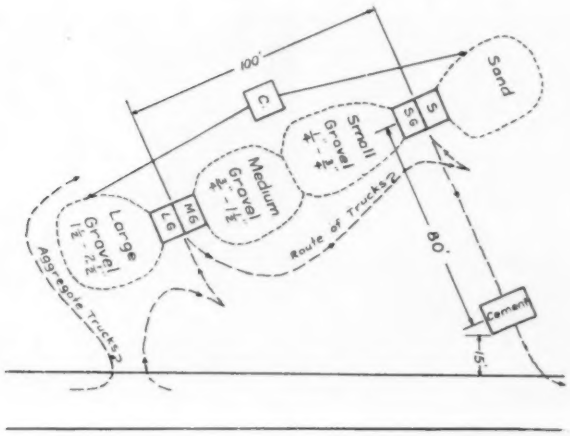
Fig. 9 shows the plant on one set-up on Wisconsin S. A. P. 2926, showing the number of turns that were required by the trucks on this job.

Fig. 10 shows the same set-up with a recommended change that could be used on similar jobs. Turning time for the trucks will be eliminated.

If but two sizes of coarse aggregate were used a three-compartment bin could have been used with one stop for the trucks. This would have been a most economical set-up and still have utilized the advantage of multiple size aggregates.

On S. A. P. 2926 the material was delivered by truck from a local pit and only one crane was necessary to supply the mixer when a 33-cu. ft. batch and a 50-sec. mixing time were used, with an average of fifty-five 33-cu. ft. batches an hour. This means that the crane handled 238,931 lbs. of sand and gravel per hour average, or about 80 cu. yds. of material per hour.

Fig. 15 shows a set-up observed this summer handled by one crane and straight-line loading method. Bulk cement was placed in the batch between the stone and sand which eliminated cover-



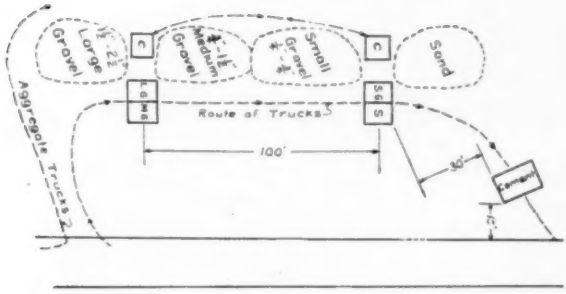
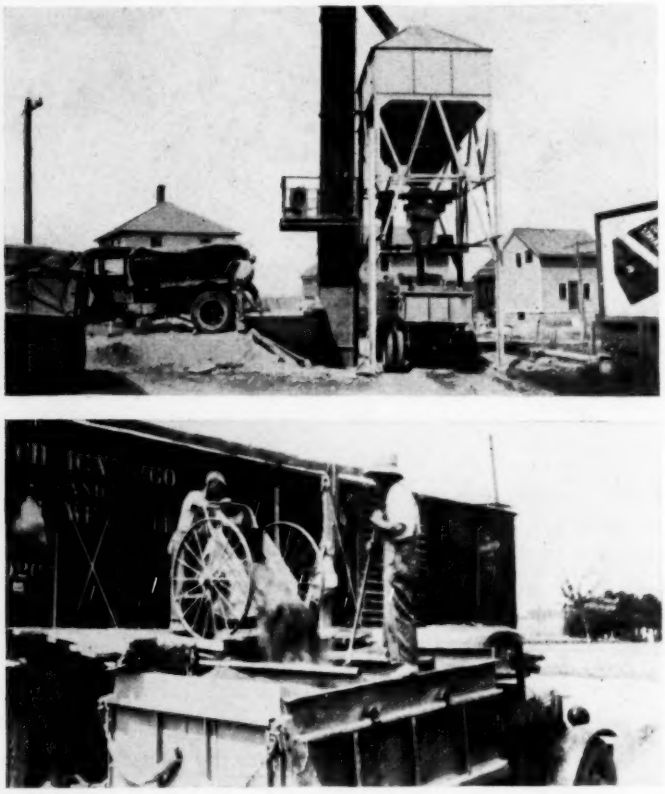


FIG. 9—PLANT LAYOUT, WISCONSIN S. A. P. 2926, SHEBOYGAN COUNTY—THREE SIZES OF COARSE AGGREGATE

FIG. 10—SUGGESTED PLANT LAYOUT, WISCONSIN S. A. P. 2926, SHEBOYGAN COUNTY—THREE SIZES OF COARSE AGGREGATE

ing the cement. This method proved very satisfactory. It eliminated having cement dumped into the skip first and choking the throat of the skip so as to retard material entering the drum. This method also eliminates the cement hitting the blades and bucket of a mixer drum causing them to become badly coated and reduce their efficiency. Some engineers prefer to have the order of loading changed to second size aggregate, sand, cement and then coarse aggregate.



FIGS. 11 AND 12—METHODS OF HANDLING CEMENT IN BULK ON S. A. P. 2916 AND S. A. P. 2926, SHEBOYGAN COUNTY, WISCONSIN

Incidentally, this contractor was using sack cement and obtained permission to try bulk cement, at a saving of eleven cents a barrel. Use of cement in bulk assures the proper weight of cement, enables a contractor to maintain a constant maximum batch and eliminates the cost of handling empty sacks. The cement retained in the sacks will average 0.4 lb. per sack. A state buying cement can make a large saving in the last mentioned item alone. As its advantages become more generally appreciated, it is believed the use of bulk cement will be extended. Up to the present time the most popular way of handling cement

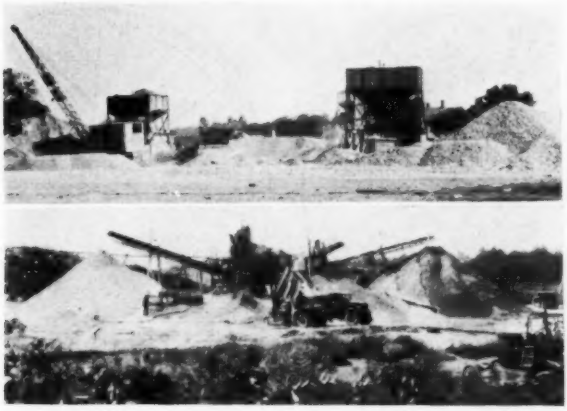


FIG. 13—TYPICAL PLANT SET-UP, S. A. P. 2926, SHEBOYGAN COUNTY, WISCONSIN. MATERIAL HAULED BY TRUCK FROM LOCAL PIT—COARSE AGGREGATE IN THREE SIZES

FIG. 14—LOCAL PIT PLANT LAYOUT EQUIPPED FOR THREE SIZES OF COARSE AGGREGATE FOR S. A. P. 2926, SHEBOYGAN COUNTY, WISCONSIN

in bulk at the batcher plant is with two-wheeled concrete buggies. Two cars of cement are unloaded at the same time. A wooden platform is constructed to the same elevation as the box car floor and with a length sufficient to reach the doors of both cars. Usually two men are used in each car loading the buggies, two men to wheel the buggies to a platform scale, two men to weigh

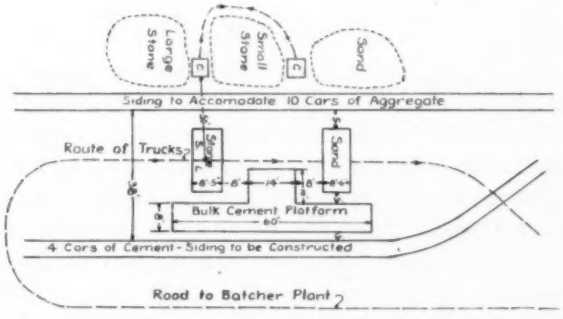


FIG. 15—TYPICAL STRAIGHT-LINE LOADING, ADAPTED FOR CEMENT IN BULK; TRUCKS LOADED MECHANICALLY OR WITH CONCRETE BUGGIES; SAND USED TO COVER CEMENT

FIG. 16—COST CHART FOR CONCRETE PAVING PROJECT 1

Cement hauled by truck directly to bulk cement plant. Aggregates from local producing plant—cost includes delivery to batching plant. Depreciation figured on 11.27 miles of pavement—life of paver taken as 55 miles. Concrete design: 5 sacks of cement per cu. yd. of concrete, 6 gallons water per sack of cement, and b/b$_o$ of .76. Mix by weight—1:2.67:4.67. Total cost per sq. yd. $1.362. Length of project 11.273 miles. Average length of haul 1.96 miles.

FIG. 17—COST CHART FOR CONCRETE PAVING PROJECT 2

Cement delivered in bulk by rail and handled in carts. Aggregates from commercial plant, delivered by rail—cost includes freight. Depreciation figured on 10.00 miles of pavement—life of paver taken as 50 miles. Concrete design: 5 sacks of cement per cu. yd. of concrete, 6 gallons water per sack of cement, and b/b$_o$ of .76. Mix by weight—1:2.71:4.68. Total cost per sq. yd. $1.472. Length of project 9.88 miles. Average length of haul 1.97 miles.

and finally dump the cement into the trucks.

On Wisconsin S. A. P. 2916, (Figs. 6, 8 and 12), the bulk cement was delivered by rail and the concrete buggies employed to handle the cement. On Wisconsin S. A. P. 2926 the cement was delivered on the job in trucks and the cement loaded mechanically. Both methods proved very satisfactory and the trucks could be loaded rapidly with no apparent loss of cement during loading or in transit. Sand was dumped on the coarse aggregate so that it could be pocketed and the bulk cement covered with the loose sand. Both jobs employed straight-line loading of the trucks with the bulk cement. This eliminated unnecessary turning or backing of the trucks.

Delaying a three-batch truck one minute represents a loss

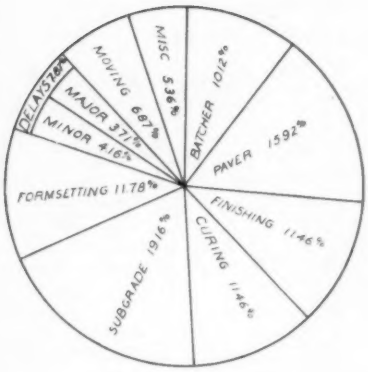


FIG. 18—LABOR COST CHART FOR CONCRETE PAVING PROJECT 1

Major delays: Unavoidable delays over 15 minutes in duration. Minor delays: Unavoidable delays under 15 minutes in duration. Cement handled by bulk cement plant and delivered directly by trucks. Moving includes that occurring during job. Concrete design: 5 sacks cement per cu. yd. of concrete, 6 gallons water per sack of cement, and b/b$_o$ of .76. Mix by weight—1:2.67:4.67. Total cost per sq. yd. $0.1260. Length of project 11.273 miles. Average length of haul 1.96 miles. Hauling by sub-contract—labor not included on chart.

FIG. 19—LABOR COST CHART FOR CONCRETE PAVING PROJECT 2

Major delays: Unavoidable delays over 15 minutes in duration. Minor delays: Unavoidable delays under 15 minutes in duration. Cement handled in carts and delivered in bulk by rail. Moving includes that occurring during job. Concrete design: 5 sacks cement per cu. yd. of concrete, 6 gallons water per sack of cement, and b/b$_o$ of .76. Mix by weight—1:2.71:4.68. Total cost per sq. yd. $0.1287. Length of project 9.88 miles. Average length of haul 1.97 miles. Hauling by sub-contract—labor not included on chart.

of about five cents. This item may seem small but it accumulates rapidly into a larger sum. Delaying the mixer one minute often represents a loss of about one dollar. On a paving job where operations should synchronize and coordinate, seconds lost are dollars wasted. An efficient batching plant removes many chances for delay.

Tables 1 and 2 show summaries from the time studies made during June to October on the Sheboygan county, Wisconsin, jobs. These data were obtained by careful stop-watch studies made every day of all operations to determine the mixer delays in seconds of less than fifteen minutes in duration, which were classified as minor delays, and delays of greater than fifteen minutes, which were grouped as major delays. In both minor and

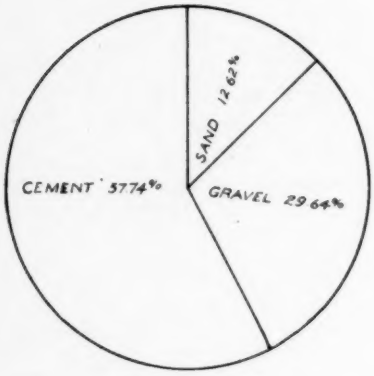


FIG. 20—COST CHART FOR CONCRETE MATERIALS PROJECT 1

Aggregates from local producing plant—cost includes delivery to batching plant. Bulk cement used. Concrete design: 5 sacks cement per cu. yd. of concrete, 6 gallons water per sack of cement, and b/b$_o$ of .76. Mix by weight—1:2.67:4.67. Total cost per sq. yd. $0.749. Length of project 11.273 miles. Average length of haul 1.96 miles.

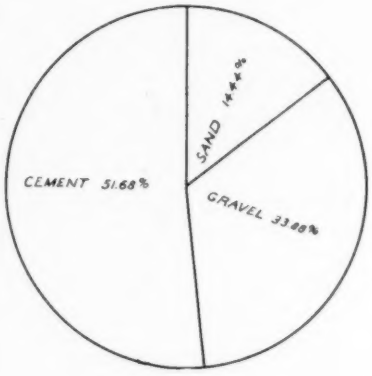


FIG. 21—COST CHART FOR CONCRETE MATERIALS PROJECT 2

Aggregates from commercial plant, delivered by rail—cost includes freight. Bulk cement used. Concrete design: 5 sacks cement per cu. yd. of concrete, 6 gallons water per sack of cement, and b/b$_o$ of .76. Mix by weight—1:2.71:4.68. Total cost per sq. yd. $0.837. Length of project 9.88 miles. Average length of haul 1.97 miles.

major delays, those believed to be unavoidable were classified as "A" and those believed to be avoidable as "B."

In noting the losses that occurred on the job, delays due to separated sizes are negligible, except on the job where the plant space was limited because of the four stock piles and the crowded conditions that existed. The job started with one crane but as production was improved. another crane had to be put on the job. Probable causes of delays were forecast on the job and through the contractor's cooperation in using suggestions to remedy them, delays of any consequence due to handling the separated aggregates did not occur.

Figs. 16-21 show the data collected on the Sheboygan county jobs. These charts illustrate the costs involved in constructing the concrete pavement, where both jobs had practically the same truck haul with the overall efficiency of one contractor 83.1 per cent, and the other 88.0 per cent. One job used local aggregate

TABLE 1—SUMMARY OF TIME LOSSES AND THEIR EFFECT ON PRODUCTION

Wisconsin S. A. P. 2, June 23 to August 21, 1930

Total *major* delays occurring during available working time	Class A		Class B			
Character	Hours	Per Cent	Hours	Per Cent		
Haul unit, supply			0.25	0.04		
Mixer trouble, mechanical	4.08	0.75				
Water supply	3.13	0.57	0.50	0.09		
Lack of materials at yard	0.77	0.14				
Crane trouble, mechanical	10.27	1.88				
Moving	83.45	15.30				
Rain	13.80	2.53				
Wet subgrade	21.25	3.90				
Miscellaneous	0.58	0.11	1.03	0.19		
					Hours	Per Cent
Totals	137.33	25.18	1.78	0.32	139.11	25.50
Time major equipment actually operated					406.07	74.50
Available working time, hours					545.18	100.00

Total *minor* delays occuring during time of actual operation	Class A		Class B			
Character	Hours	Per Cent	Hours	Per Cent		
Haul unit, supply			14.95	3.68		
Haul unit, operation	1.15	0.28	9.94	2.44		
Dumping	1.28	0.31	1.34	0.33		
Mixer trouble, mechanical	2.89	0.71	0.77	0.19		
Mixer operation	0.15	0.04	9.32	2.29		
Water supply			12.88	3.16		
Lack of materials at yard			0.33	0.08		
Subgrade not prepared			6.98	1.72		
Set parting strip			0.51	0.12		
Place reinforcing steel	1.27	0.32	0.07	0.02		
Wait for finishers	1.44	0.35	0.60	0.15		
Sand batch, lip curb	0.47	0.12	1.02	0.25		
Expansion joint			0.38	0.09		
Crane operation	3.03	0.74				
Miscellaneous	1.02	0.25	1.86	0.46		
					Hours	Per Cent
Totals	12.70	3.12	60.95	14.98	73.65	18.10
Time major equipment operated at 100 per cent efficiency					332.42	81.90
					406.07	100.00
Grand total of all Class B losses, hours					62.73	
Possible operating time, all Class B losses eliminated					395.15	
With all Class B losses eliminated, production would have been	18,972 batches				110,000 sq. yds.	
Actual production	15,945 batches				92,395 sq. yds.	
Overall efficiency of major equipment operation					83.1 per cent	

TABLE 2—SUMMARY OF TIME LOSSES AND THEIR EFFECT ON PRODUCTION

Wisconsin Project 1, Sheboygan County

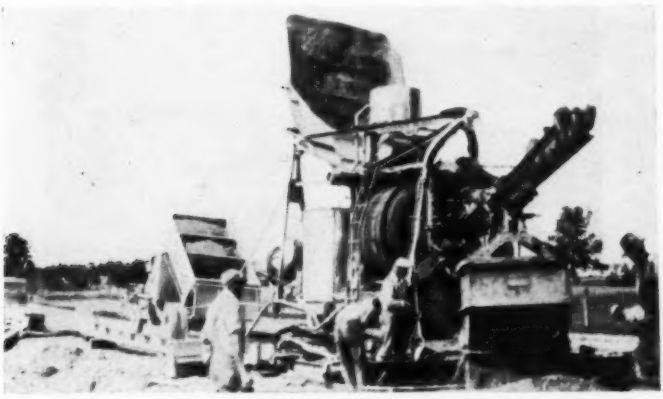
Summary of all delays for job:

Total available working hours—613.0 Total production—116,347 sq. yds.

Total *major* delays occurring during available working hours	Class A		Class B		
Character	Hours	Per Cent	Hours	Per Cent	
Rain	31.75	5.19			
Wet grade	32.50	5.30			
Moving during job	35.25	5.75			
Material supply	24.75	4.04	1.50	0.24	
Subgrade	8.00	1.30			
Mixer trouble, mechanical	3.07	0.50			
Water supply	2.50	0.41	0.33	0.05	
Batcher	3.50	0.57	1.78	0.29	
Finishing machine	1.95	0.32			
Crane	5.50	0.90			
Joints			1.50	0.25	
Miscellaneous	4.75	0.78	1.10	0.18	
Totals	153.52	25.06	6.21	1.01	Total all *major* delays: 159.73 (Hours), 26.07 (Per Cent)
Time paver actually operated					453.27, 73.93
					613.00, 100.00

Total *minor* delays occurring during time of actual operation	Class A		Class B		
Character	Hours	Per Cent	Hours	Per Cent	
Hauling supply	0.19	0.04	7.46	1.65	
Hauling operation	0.11	0.02	4.20	0.93	
Dumping	0.84	0.19	5.41	1.19	
Mixer trouble, mechanical	4.81	1.06	0.09	0.02	
Mixer operator	0.28	0.06	8.18	1.80	
Water supply	4.94	1.09	6.36	1.40	
Joints and steel	2.63	0.58	2.30	0.51	
Subgrade	0.28	0.06	3.32	0.73	
Miscellaneous	7.37	1.63	5.42	1.19	
Totals	21.45	4.73	42.74	9.42	Total all *minor* delays: 64.19 (Hours), 14.15 (Per Cent)
Time paver operated at 100 per cent efficiency					389.08, 85.85
					453.27, 100.00

Grand total all Class B time losses, hours..... 48.95
Possible operating time all Class B losses eliminated, hours 438.03
Operating efficiency of paver 99.1 per cent
Time efficiency of paver 88.8 per cent
Overall efficiency of paver 88.0 per cent
Total possible production at 100 per cent overall efficiency—132,267 sq. yds.



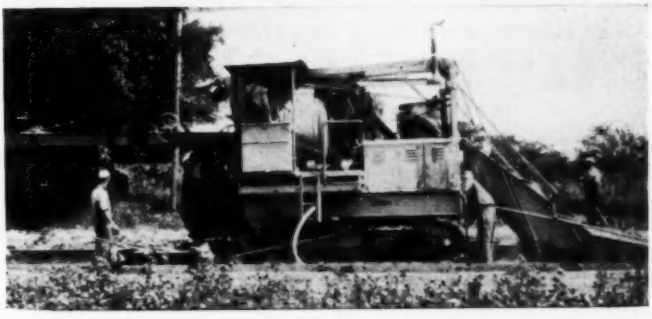


FIG. 22—TYPE OF 1926 MODEL—27-E PAVER USED ON S. A. P. 2916 AND S. A. P. 2926, SHEBOYGAN COUNTY, WISCONSIN

FIG. 23—TYPES OF 1930 MODEL—27-E PAVER USED ON S. A. P. 2916 AND S. A. P. 2926, SHEBOYGAN COUNTY, WISCONSIN

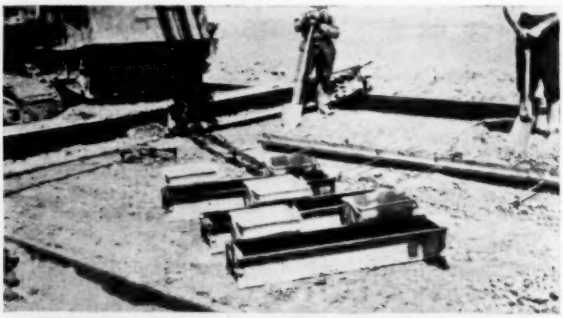


FIG. 24—METAL SAMPLE BUCKETS AND BEAM MOLDS IN POSITION TO RECEIVE CONCRETE AS DUMPED FROM MIXER SPREADER BUCKET

FIG. 25—REMOVING SAMPLE BUCKETS AND BEAMS FROM THE SUBGRADE TO THE BERM OF THE ROAD WHERE ANALYSIS IS MADE ON THE FIVE PARTS OF THE BATCH FOR THE EXACT AMOUNT OF GRAVEL, SAND, CEMENT AND WATER

and the other commercial aggregate; five sacks of cement per cu. yd. on each job.

Previous to 1930 approximately six sacks of cement were used per cubic yard of concrete on most State and Federal paving jobs. By selective grading and reducing the void content of the coarse aggregate on these two jobs, the cement reduction to five sacks per cu. yd. was made without loss of strength. A saving of approximately 6.5 cents per sq. yd. was made. Even with this reduction of cement content, the cement still forms about 30 per cent of the total cost of the pavement, and on the

FIG. 26—WASHING THE CEMENT OUT OF THE SAMPLES OF CONCRETE THROUGH A NEST OF NO. 4, 48 AND 100-MESH SIEVES

basis of the cost of the materials alone—that is, the gravel, sand and cement—the percentage is over 50 per cent. (Investigations are in progress to study the effect of cement content on the durability of concrete.)

Further reductions in hauling, labor and depreciation will be made next year in Wisconsin by the use of a 33-ft. batch and a 50-sec. mixing time after all solid material are in the drum.

On these two Sheboygan county jobs and on a Federal-aid project in Arkansas, 242 batches were sampled as they were dumped on the subgrade and tests made to determine the exact amount of coarse aggregate, sand, cement and water in samples taken from the four corners and center of the batch. From these same batches, beams and cylinders were also made—a total of 1,276 cylinders and 726 beams. Cylinders were broken at 28 days and the beams once at 7 days and twice at 28 days. The curing was the same on all jobs. The gravel obtained from the concrete sampled in the field was sieved.

These data were all obtained in connection with our study of batch size and mixing time. Table 3 gives the grand total of all data collected on each job.

The Sheboygan jobs show a slightly higher cement content than five sacks per cu. yd., because less water was used than anticipated. The water content was supposed to have been six gal. per sack of cement.

FIG. 27 (LEFT)—WEIGHING EACH BATCH PART IN AIR AND THEN IN WATER, USING THE APPARATUS SHOWN. WEIGHING WAS ACCURATE TO $\frac{1}{16}$ OUNCE

FIG. 28 (RIGHT)

One cylinder was obtained from the four corners of the batch and two from the center. Three 6 x 8 x 42-in. beams were taken from each batch. Cylinders made according to the A. S. T. M. methods. Beams were only rodded at the edges without disturbing the center mass of concrete.

On the Arkansas job the cement was supposed to have been 5.40 sacks per cu. yd. of concrete and 5.25 gal. of water per sack of cement. Because of the high temperature and high evaporation, more water was used.

The coarse aggregate used in Arkansas was a crushed trap rock and in Sheboygan, Wisconsin, a limestone gravel. The maximum size of aggregate on both jobs approximated 2½ in.

The variation on all the jobs approximate each other within one per cent and are fairly comparable in regard to actual cement and water content. Please note that the variations from batch to batch were less than the variations within the batch.

FIG. 29

Beam specimens were cured in damp sand for 28 days and tested in the field. Cylinders were cured at the same location as beams and removed in time to send to the Madison, Wisconsin, State Forestry Laboratories to be tested at 28 days.

TABLE 3—FINAL SUMMARY FOR JOBS

Job No.	No. of Batches Sampled	Proportions in Percentage by Weight				Per Cent Variation within Batch	Per Cent Variation Batch to Batch	Sacks Cement per cu. yd.	Water per Sack	Ratios by Absolute Volume			Mix by Weight	
		Gravel	Sand	Cement	Water					a/c	b/a	b/bo	Sand	Gravel
*1	118	52.56	30.11	11.35	5.97	3.90	3.07	5.16	5.96	3.02	1.72	0.746	2.67	4.67
*2	80	52.11	30.34	11.28	5.73	4.37	3.22	5.18	5.81	3.03	1.72	0.750	2.71	4.68
†4	44	48.56	33.40	11.78	6.01	4.75	3.35	5.19	5.82	3.38	1.45	0.751	2.86	4.18

*Wisconsin
†Arkansas

Job No.	Cylinders		Beam Strength						Sieve Analysis Percentage retained on				
	[1]Cylinder Strength	[2]Per Cent Variation	7 Day	[2]Variation	End[1]	[2]Variation	Center[1]	[2]Variation	2½"	1½"	¾"	¾"	4"
1	3646	6.33	598	4.55	872	4.03	866	4.76	4.0	14.8	44.3		36.9
2	3672	5.66	595	4.70	877	5.22	868	4.95	3.6	13.6	38.1		44.6
4	5039	5.89	675	6.56	723	6.04	698	5.48		21.1	56.3	16.3	6.3

[1]Breaking strength in pounds per square inch at 28 days.
[2]Variation of cylinder strengths within batch

Job No.	Maximum Cement	Minimum Cement	Maximum Water	Minimum Water	Maximum Cylinder Strength	Minimum Cylinder Strength	Beam Strengths					
							7-Day		End[1]		Center[1]	
							Max.	Min.	Max.	Min.	Max.	Min.
1	5.49	4.83	6.38	5.58	4031	3266	633	562	919	826	919	814
2	5.64	4.69	6.55	5.15	4012	3325	631	560	934	819	918	810
4	5.72	4.63	6.69	5.12	5323	4756	737	621	779	673	748	648

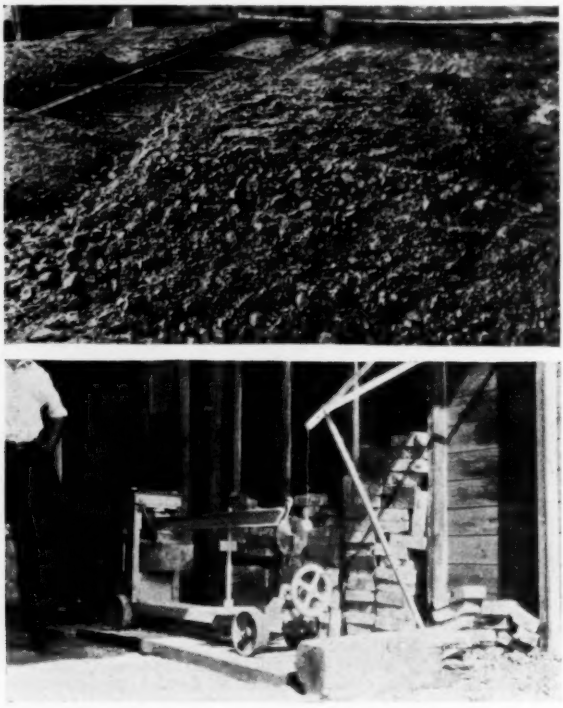


FIG. 30

The last cubic foot of concrete discharged from any make of mixer has a predominance of coarse aggregate. Therefore approximately a cubic foot of concrete should be retained in the mixer drum. Also the design of mixer spreader bucket causes segregation. The results of these two cause a batch to appear such as shown in the above photograph.

FIG. 31—THE BEAM TESTING MACHINE AND THE LOAD OF APPLICATION WAS CONTROLLED TO BE THE SAME ON ALL SPECIMENS AND TESTED BY THE SAME OPERATOR

Even by visual inspection one could see on these jobs that variations from batch to batch were reduced by using separated sizes for the coarse aggregates. This was valuable in reducing delays at the mixer, where ordinarily a concrete produced with a very low water content and low cement factor gives occasionally an extremely dry batch which almost invariably delays the finishing operations.

Variations within a batch will apparently be hard to eliminate

no matter what the size of the batch (our tests cover batches varying from 27 to 35 cu. ft. in a 27-E paver), or whether the concrete is mixed more than 50 seconds after all the solid materials are in the drum. The variations within a batch become larger as the range from small size aggregate to large size aggregate becomes larger.

In general terms a slab is no stronger than its weakest batch, and each batch is no stronger than its weakest part. Therefore, we must work toward the most advantageous equalization of both the variations between batches and the variations within the batch. It follows we should not attempt to have the variation from batch to batch reduced by too costly refinements below the variation within a batch. This, I believe, is the answer to the question, "How many separated sizes of coarse aggregate should be used?"

To reduce variations from batch to batch beyond a certain point costs money. In some, probably many cases, the use of separated sizes of coarse aggregate can be made to yield a net profit. The extent to which this process can be pushed, however, seems to have a definite limit, in that the cost is likely to increase progressively as the variations are reduced. To press the reduction in the variations from batch to batch too near the same value as the variations within the batch would therefore bring us within the field of diminishing returns. And to bring the variations between batches below the variations existing within the batch would seem to be of little use, even though this could, by some happy chance, be accomplished at no extra cost.

If oversanded mixes are still retained after the introduction of the use of aggregate of multiple sizes, the added expense is a loss. It is obvious that by using separated sizes intelligently a lower mortar ratio can generally be used, and as a consequence the cement factor can be reduced. The extent to which this can be done for any given extra cost will form a measure of what saving can be expected from using separated sizes of coarse aggregate in concrete road construction.

DISCUSSION

BY A. L. HAMBRECHT*

The Department of Commerce reports show one hundred million barrels of cement manufactured in 1920 which represents an increase of approximately 26 per cent over the amount manufactured in 1910 and a further increase of approximately 70 per cent from 1920 to 1930. A large part of the increase shown for the 1920-1930 decade is accounted for by the increased highway construction programs of that period.

To meet the demands of the added construction there followed a development and improvement of various types of paving equipment which is probably unparalleled in any other line of industry. Compare the modern concrete paving outfit of comparatively few men and nearly perfect coordination between the various units with the more or less disjointed, inefficient paving outfit commonly used prior to 1920—a large number of men who spent a considerable part of their time side-stepping to avoid colliding with each other—wooden forms in various stages of disintegration—stock piles of aggregates on the subgrade, more likely than not covered with a liberal layer of dust—a maze of plank runways—a collection of decrepit wheelbarrows—a wheezy old alley steam paver—and last but not least the man-killing, hand operated strikeoff boards. As we contemplate this we cannot help but wonder why the old order held forth as long as it did.

The sudden and unprecedented increase in the use of portland cement concrete for paving caught highway engineers more or less unprepared with the result that, except in a few isolated cases, the art of concrete manufacturing from the standpoint of the concrete itself did not receive a great deal of attention. Arbitrary proportions were specified—the aggregates were proportioned by volume without correction for bulking—the amount of mixing water added to the batch was left entirely to the judgment of the mixer operator with the result that the batch to batch consistency varied greatly.

The importance of controlling and maintaining uniform amounts of aggregates in the batches and maintaining a uniform con-

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sistency was recognized and resulted in the almost universal adoption of weight proportioning and the installation of accurate water measuring devices on paving mixers.

The several theories of proportioning and designing concrete mixtures whether it be by arbitrary assignment, fineness modulus, maximum density, water cement ratio or voids recognize the importance of maintaining uniform proportions of the materials if uniform results are to be obtained. This necessitates accurate measurement of all materials. The character of sand is such that segregation in handling is negligible and the volume of the given sand is approximately uniform when dry. Sand can easily be weighed to a high degree of accuracy and moisture corrections easily and accurately made. The coarse aggregate, however, presents a more difficult problem. By weighing a definite absolute volume can be maintained. The apparent volume, however, will vary as the gradation varies. When we consider that we are dealing with a material with a range in gradation from 2½ in. to ¼ in. or 1½ in. to ¼ in., and the frequent handling required between the producing plant and the placing in the forms it becomes apparent that wide variations can and do exist from the gradations originally specified. Even with the utmost care in stock piling we find an accumulation of finer particles in the center and an excess of coarser particles on the outside of the pile.

The tendency of coarse aggregate to segregate and the resulting variation in apparent volume, voids and surface areas, which in turn affect uniformity of water content, mortar content, workability and yield is a real obstacle to concrete control. Variations of 15 per cent in the voids of equally proportioned coarse aggregates due to segregation and poor gradation frequently occur and such variations can easily cause a 10 per cent batch to batch variation in cement content per unit volume of concrete.

The separation of coarse aggregate into several sizes, thereby maintaining the voids at a uniform minimum and the use of a uniform minimum amount of mortar consistent with workability will tend to insure a reasonably uniform product for any given combination of materials.

During the 1930 construction season the use of coarse aggregates in separated sizes was required by the Wisconsin Highway Commission on a number of paving and bridge projects. The

materials used consisted of those most commonly used in concrete work in this state, namely, calcareous or dolomitic gravel, igneous or granitic gravel and crushed limestone. The aggregate for one project was produced from a local pit and the other projects were supplied by commercial plants.

The coarse aggregate for the paving projects was required to be furnished within the following gradations: limestone and calcareous type gravel in three sizes, ¼ in. to ¾ in., ¾ in. to 1½ in. and 1½ in. to 2½ in. Igneous type gravel in two sizes, ¼ in. to ¾ in. and ¾ in. to 1½ in. For bridge work the maximum size allowed is 1½ in.

The production of coarse aggregate in separated sizes whether by a commercial plant or by the contractor from a local pit will in most cases require plant changes consisting principally in providing increased screen capacity to permit a close separation of sizes. Commercial producers will readily agree to accept this method as they have for some time been attempting to effect a standardization of commercial sizes.

On our 1930 work, which can be considered of an experimental nature, no difficulty was experienced in securing the required sizes from commercial plants or in the local pit production.

In handling rail-shipped aggregates from cars to stock piles or proportioning bins, side track and yard space available will control the size of stock piles and general arrangement of plant and equipment. Two double compartment bins will be required when using three sizes of coarse aggregate and two cranes will be necessary to avoid delays except under the most favorable arrangements. The pictures shown by Mr. Thee give some idea of the restricted space available for stock piles, proportioning bins and cement handling platform on the Johnson job. The arrangement while inconvenient did not appreciably affect production.

On the project where two sizes were used a single crane easily kept the three compartment bin fully charged.

With the locally produced material the aggregates were hauled by truck from the producing plant and stock piled on an area adjacent to the project. The arrangement of bins and stock piles enabled a single crane to handle the material without causing any delays.

The use of two bins introduces added costs for equipment and the extra batch operator and involves some lost time for the trucks. The additional batching time required will depend upon the distance between and the accessibility of the bins. With two sizes of coarse aggregate, using a three compartment bin there was no noticeable increase in the time required for batching.

With all of the materials entering each batch accurately controlled the resulting concrete as deposited on the subgrade has a decidedly uniform appearance. There were no batches with an excess of coarse aggregate or an excess of mortar, a common occurrence on projects using a single size of coarse aggregate. Other factors being equal, uniformity of concrete will to a great extent eliminate the unequal shrinkage or settlement responsible for many of the present pavement surface irregularities.

The views showing the placing and finishing of the concrete indicate an excess of mixing water. This did not generally prevail on our work and we try to maintain a consistency which will give a slump of about 1½ in. and further limit the mixing water to 6 gal. maximum per sack of cement.

A comparison of results obtained on two projects, one using separated sizes and the other a single size, indicates that close control of the proportioning of aggregates produces concrete of greater uniformity. As the following will indicate, the projects were built at the same time of the year and were within 30 miles of each other. The aggregates were supplied from the same commercial plant and the proportions were identical except for the separated sizes. The average strength of the specimens using separated sizes was 11 per cent greater than the average strength using the single size. On the job using recombined aggregates all breaks were within 10 per cent above or below the average and of the total of 53 breaks only two tested more than 5 per cent above and only 6 tested more than 5 per cent below the average.

The variation in strengths on the job using the single size of stone ranged from 25 per cent above to 25 per cent below the average and of the total of 41 breaks 16 tested more than 5 per cent above and 16 tested more than 5 per cent below the average.

These results are generally typical of the results obtained on other projects.

An analysis of the concrete as it is discharged from the spreader

bucket indicates that there is a variation in the relative proportions of coarse aggregate, fine aggregate, cement and water in different parts of the batch. In a typical series of tests the following variations existed. The cement content varied from 4.79 sacks to 5.42 sacks per cubic yard. The water varied from 4.96 gal. to 5.45 gal. per sack of cement. The sand cement ratio varied from 2.99 to 3.14. The gravel sand ratio varied from 2.10 to 1.53 and the ratio of the absolute volume of coarse aggregate in a cubic foot of concrete to the absolute volume of coarse aggregate in a cu. ft. of coarse aggregate or the b/b_o varied from .845 to .749.

It is therefore evident that unnecessary refinements in gradation which would tend to increase costs would be unwarranted unless the interior of the mixer drum and spreader bucket can be designed to overcome the variations noted above.

The results obtained by the use of separated sizes of coarse aggregate on the 1930 work have convinced us that it is a construction detail that should be recognized in designing concrete mixes, when a relatively high percentage of coarse aggregate is used. The type and character of materials available and the combinations possible with them can materially affect the final cost without sacrificing quality.

BY GEO. LANGLEY, JR.*

My position as County Highway Engineer placing me, as it does, in direct field contact with construction work, and in direct contact with the people to whom I am responsible (the tax-paying public) necessarily inclines me to consider the theories involved in the design of concrete mixtures, from the thoroughly materialistic rather than from the profoundly abstract viewpoint.

From 1927 to 1930 inclusive, Sheboygan county has constructed 80 miles of portland cement concrete highway pavement.

In 1927, 5 miles were constructed using the Wisconsin Highway Commission specification, 1:2:4 proportioning with all measurements by volume.

Twelve miles were constructed in 1928 again using the Wisconsin Highway Commission specification 1:2:4 proportioning, the coarse aggregate measured by volume, and the fine aggregate

*County Engineer, Sheboygan County.

measured by weight with corrections for moisture content and bulking factor.

Thirty miles were constructed in 1929 using a designed mix, both aggregates being measured by weight, without separating and recombining the coarse aggregates.

Thirty-three miles were constructed in 1930 using a designed mix, measurements by weight and the coarse aggregate separated into three sizes and recombined in the batch.

Of these 33 miles about 23 miles were constructed under the observation of, and subject to tests by the Division of Management, U. S. Bureau of Public Roads. Specifications on this 23 mile construction called for the use of four different sized batches, 27, 30, 33 and 35 cu. ft. as directed by the engineer in charge. Unit prices were received on each batch size, the average contract price of the 27 cu. ft. being 3¢ per square yard greater than the 30 cu. ft. batch, and the 30 cu. ft. being 2½¢ more than the 33 or 35 cu. ft. batch.

Test results on the concrete produced during these four years were as follows:

Year	Flexural Strength		Compressive Strength		
	7 Day Beams Average Mod. of Rup. lbs. per sq. in.	28 Day Beams Average Mod. of Rup. lbs. per sq. in.	Cylinders 28 Days lbs. per sq. in.	Cores-Age 6 Months lbs. per sq. in.	Cement Content per cu. yd.
1927	None	None	None	None	1.6 Bbls.
1928	None	None	None	3960	1.39 Bbls.
1929	521	665	None	4250	1.24 Bbls.
1930	590	861	3665	To Date 5680	1.25 Bbls.

The tests taken and records kept during 1930 by the Division of Management, U. S. Bureau of Public Roads were very complete. Sheboygan county has a definite program calling for the construction of 45 miles of the same type of highway. It follows, of course, that we, desiring to profit by the records of past experience, are making an exhaustive study of these records.

The outstanding facts gleaned from our test records of the past four years are:

1st: An increase of 40 per cent in compressive strength in 1930 as compared to 1928.
2nd: An increase of 30 per cent in flexural strength in 1930 as compared to 1929.
3rd: Constantly increasing control of proportioning of aggregates.
4th: Constant decrease in the quantity of cement per cubic yard of concrete.
5th: Constant increase in rate of production.

Certainly, the increased strength of the concrete, together with an increase in density, should indicate increased durability, at least insofar as the effects of changes in temperature are concerned.

The decrease in cement content made possible by careful proportioning of the aggregates and the increase in production due to increase in batch volume and decrease in mixing time are, of course, of enormous economic value.

It will be noted by reference to Fig. 3 and 4 of Mr. Thee's paper that by decreasing the cement content from six to five bags per cu. yd. there was a reduction of 6½¢ per sq. yd. in the cost of the pavement. As Sheboygan county built 33 miles of concrete pavement last year, the saving in cement cost was $26,100.00.

The saving in cost due to the increase in the volume of the batch amounted to 5½¢ per sq. yd. Consequently, the saving due to this item was $21,240.00, or a total saving on the 33 miles of $47,340.00. This total of $47,340.00 was 20 per cent of the total general property tax for highway purposes in Sheboygan County in 1930.

It is evident from the records, that close control of the aggregates makes possible a considerable saving in cost.

In our experimental use of three sizes of coarse aggregate, we confined ourselves to the use of such equipment for this separation as was available and made every effort to avoid changes in this equipment.

Coarse aggregate proportions to fit the existent production conditions were used.

Screen equipment at production plants was such as to make it impossible to obtain efficient separation. An over run of sizes sometimes as great as 50 per cent was noted.

It is evident that if crushers are adjusted to produce coarse

aggregate in the most advantageous proportions and sufficient screen area used to insure complete separation, much closer control of the proportioning of the aggregates may be obtained.

Records from other localities show that coarse aggregate with a maximum size of three and one-half inches is being used with no detrimental effect on the strength of the concrete. The use of a 3½-in. maximum size of coarse aggregate would reduce the cost of production of the aggregate. It would also make it possible to obtain a larger percentage of absolute volume in a cubic yard of coarse aggregate.

Bins are already planned by equipment manufacturers to make it possible to load the truck with one stop, thus eliminating much of the extra truck cost of last season.

Inasmuch as it has been our experience to note, and our records plainly indicate, that as we gained closer control of the proportioning in the materials, the quality of the concrete improved and the cost decreased. I find it hard to accept Mr. Thee's conclusion that two sizes of coarse aggregate are sufficient.

Mr. Thee's conclusion is based, of course, on cost records of last year, and I fear that the methods used in the separating and recombining of the coarse aggregate were too crude to reflect true cost.

It seems possible that the continued use of three sizes of coarse aggregate may bring about more efficient equipment and methods, so that the benefits derived will warrant the cost.

I believe that with control of proportioning as near perfect as possible, the cement content per cu. yd. of concrete need not be arbitrarily specified, but that it is dependent on the gradation of the materials used.

It seems evident that if in a cubic yard of concrete, the greatest amount of absolute volume of coarse aggregate practical, from the viewpoint of workability, is used, the amount of mortar required will be the minimum.

It seems just as evident, that if the absolute volume in the quantity of sand required for the mortar is the greatest obtainable, the cement content requirement of the mortar will be the minimum.

Such a combination of materials should not require too large an amount of water to bring about the necessary degree of work-

ability, and even if too much water is placed in the mixture, the excess quantity will be eliminated in placing and finishing the slab, so that a proper water cement ratio will be effective before hardening takes place. It is our belief that the water cement ratio of concrete in a highway slab pavement is in no way affected by the quantity of water, within reasonable limits, placed in the mixer, provided, of course, that there is sufficient water to hydrate the cement used; also, that the quantity of water, after the concrete is in place on the subgrade and has received its final working, and is ready to set, establishes the effective water cement ratio, and that this ratio is to a considerable extent dependent upon the gradation of the dry materials used in the concrete.

If materials of a proper gradation are obtainable, a computation of proportions is both possible and plausible, and this computation is a matter of field practice and does not necessarily need laboratory test.

To me the test records of our work of last season indicate that the cement requirement per cu. yd. with which to obtain the greatest strength possible can be computed, and that it is materially (at least 10 per cent) less than that used last season.

After our experimental experiences of the past in the design of concrete mixtures, I feel that tests should be taken in the field to determine the relative values of the various different types and brands of cement.

In conclusion, I wish to express my appreciation of the fact that I was allowed a small part in the cooperative studies of last year, and the hope and desire that these cooperative studies be continued during the coming season. Surely the benefits derived from field research are worth the investment.

Readers are referred to the JOURNAL *for December 1931, (Vol. 28) for further discussion which may develop. Such discussion should reach the Secretary by Nov. 1, 1931.*

Design and Operation of Central Mixing Plants

*Progress Report of Committee 603**

BY FRANK I. GINSBERG† AUTHOR-CHAIRMAN

The development of the central concrete plant as a commercial undertaking has been so rapid that there is yet scarcely time in which to have built up any "best designs" or "best operating methods" which are complete and comprehensive. It seems the proper function of the committee now, as Mr. Ginsberg has written, to outline recent progress, note some clearly developed pitfalls to be avoided and to stimulate discussion among the many active in plant design and operation. Several members of the committee participated in a symposum at the 26th Annual Convention, New Orleans, reported in this Journal March 1930, Vol. 26, p. 551. The present report prepared by the author-chairman has been submitted to the critic members of the Committee: Joseph E. Burke, Miles N. Clair, N. D. Crowley, G. L. Lucas, A. W. Munsell, H. F. Thomson, Fred C. Wilcox, all of whom give it general approval and some of whom expect to submit independent discussion. Mr. Ginsberg acknowledges his gratitude to the members of the committee for their general cooperation.—EDITOR

INTRODUCTORY

IN THE LAST three years there have been marked changes in the design of central plants due to the development of the ready-mixed concrete business, which has rapidly changed the picture in the manufacture of concrete. The primary purpose of this report is to outline progress in central plant design during this period, and second to develop discussion that will result in a

*Presented at the 27th Annual Convention, Milwaukee, Feb. 24-26, 1931.
†Vice-President, H. O. Penn Mach. Co., Inc., 140 St. and East River, New York City.

sound basis of control and the most economical production methods in the manufacture and delivery of central plant concrete. It is a far cry from the old haphazard methods of mixing concrete by the feeding of materials measured and controlled by the rule-of-thumb method, to the present precise mechanically controlled weighing devices and efficient material handling machinery. Much has been accomplished in this direction and the future developments in this industry will bring much more efficient methods in the control and the economic handling of central mixed concrete.

The conditions that will govern the design and arrangement of a plant for the production of ready-mixed concrete are controlled by a number of local factors. The location of the plant with reference to the possible consumption and use of concrete is important. The size and type of plant will of necessity be entirely controlled by these local conditions.

It is surprising to note that in towns with a population of 15,000 to 20,000 there have been as many as three plants in operation, all of which seem to be getting along successfully. This, however, is most unusual and is not generally practicable. There is, however, a potential outlet for ready-mixed concrete in small localities where there is considerable road work or street paving to be done, which may in some cases justify larger plants than really indicated by the more obvious conditions.

The method of receiving materials, whether by rail, truck or water, also controls the size and type of plant.

There has been considerable difference of opinion, whether the most efficient and practicable plant is to be the central mixing plant or the central proportioning plant.

TYPES OF CENTRAL PLANTS

The central mixing plant is one in which the materials are proportioned and mixed in a concrete mixer at the plant and delivered in agitating or non-agitating trucks to the point of final deposit.

At a central proportioning plant materials are all proportioned and batched into a mixer type of truck body, in which mixing is done enroute with water added to the batch in the truck, or mixed on arrival at the job.

Each type of plant has some advantages and from such tests as have been made at the time of leaving plant and the time of final deposit, there seems to be no appreciable difference.

There is also a design of plant recently developed which combines a central mixing plant and a central proportioning plant, and which is used for both purposes as occasion requires.

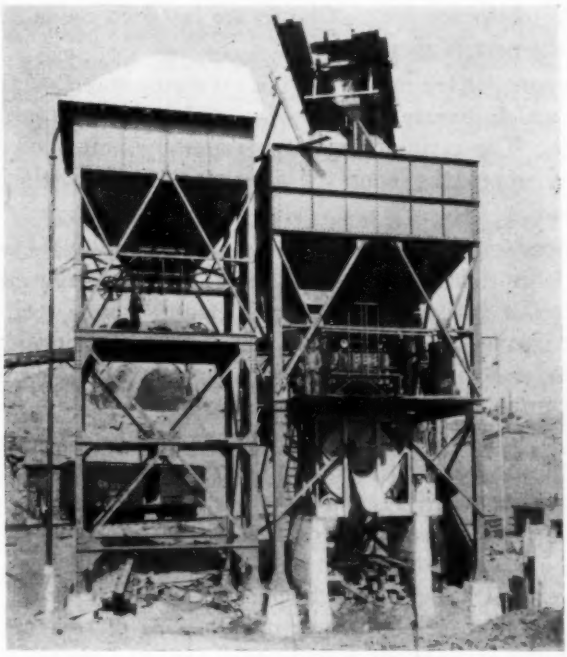

FIG. 1.—LOIZEAUX BUILDERS SUPPLY CO., ELIZABETH, N. Y.

PLANT EQUIPMENT AND METHODS

Bins. Steel bins have come into general use in nearly all types of central plants, and the weighing method of controlling the proportions of materials has supplanted the older methods of volumetric measurement. Material bins are generally divided for the storage of from four to six classes of aggregates and there are some occasions where storage of eight classes of materials has been provided for, but this is not usual.

Unloading Facilities. Where water facilities for receiving materials are available, the material is generally unloaded by crane or derrick directly into the bin. In some cases derricks are preferred to cranes because of the height of the bin, which ranges from 35 to 50 ft., depending of course, on the size and capacity of the bin itself. In under favorable conditions a crane unloads into a small hopper at the dock, and belt conveyors elevate the materials to storage bins. Cranes are faster in unloading where bin heights permit their use.

Conveyors deliver materials to a revolving spout on the top of the bin, which diverts the flow of materials into the proper compartment. The revolving spout is generally controlled from the platform, where the operator governs the proportions of the materials.

Where materials are delivered to the plant by rail the general method is as follows: Bottom-dump standard gauge cars drop the materials into a track hopper, from which reciprocating feeder or belt feeder delivers to a belt conveyor, thence to the top of the bin, and in some cases to a bucket elevator, or where conditions permit, the materials are delivered directly to a bucket elevator from the feeder, which in turn elevates the material to the top of the bin into a revolving type of hopper, from an extended chute at the top of the elevator. The unloading of standard gondola cars by derrick or crane clamshell bucket methods is also used extensively.

The vertical type of steel-enclosed elevator seems to have worked out best on permanent installations of this type. The choice of elevators is most important and the proper design of this unit and capacities must be given careful consideration. It is recommended that in large plants elevators have a minimum capacity of 100 cu. yds. per hour and be preferably, of the continuous type with double-strand chain and steel buckets; and that automatic brakes be installed against possible power line troubles while this unit is in operation.

Where the delivery of the materials must be made to the plant by truck, the general practice is: To arrange a form of grill work where the truck discharges the material directly into the boot of the elevator or into the hopper of a belt conveyor. There should be a gate on the hopper of the belt conveyor or bucket elevator

to permit control of the feeding of the materials on the respective units. In some instances, a long belt conveyor is used and the material discharged onto the belt conveyor through a series of gates. This is known as the tunnel belt method of storing and handling aggregates and is in successful use in a number of plants throughout the country. This belt runs horizontally under the stock piles and is then inclined to the revolving hopper on top of bin. The angle of this inclined section is generally from 18 to 20 deg. and in no case should this angle exceed 24 deg.

A method of delivering concrete materials in containers transported on gondola cars has been developed recently by some of the eastern railroads. The containers are open-top rectangular steel boxes, usual capacity about six tons, with twelve boxes on each car. The containers are of bottom-dump type; are handled by crane or derrick and can be used for sand, stone or cement.

HANDLING CEMENT IN BULK

The use of bulk cement is developing very rapidly, and suitable provision is being made by the manufacturers of bin and batching equipment so that the control of this material is properly coordinated with the control of the fine and coarse aggregates. There are a number of methods for handling bulk cement.*

One method is in delivery of cement in box cars or specially designed bottom-discharge cars from which cement is unloaded into hoppers through screw conveyors and elevated into cement storage bins. Cement from the storage bin is then handled by various devices such as screw conveyors, bucket elevators, into auxiliary storage bins directly over the cement weighing hoppers or by screw conveyors with electric push button controls feeding directly into a cement weighing hopper. It is suggested that in all cases where cement is being used in bulk, that it be delivered into a separate compartment for cement only after being weighed and then discharged into the mixer through properly arranged chutes.

There have been a number of instances of cement being weighed in the same hopper in which the aggregates have been weighed. This, however, is not recommended because the cement will build up on the wet surfaces of the aggregate weighing

*Committee 607, Use of Cement in Bulk. Herbert Coffman, author-chairman, presented a report at the 27th Annual Convention. It is scheduled for publication in the JOURNAL for Sept. 1931, Vol. 28.—EDITOR

hopper. The use of compressed air equipment for unloading and delivering cement directly into the cement storage bin is coming into more use and devices have been developed for unloading the cement directly from box cars or boats and pumping it into the storage bins without the additional use of power shovels or hand shovel methods that have been necessary in handling bulk cement to date.

The compressed air pumping system is widely and successfully used in the handling of bulk cement in central plants. Electric power is generally used for the cement pump and for the compressor unit. Automatic signal arrangements have been devised to show when the bins are full, to prevent overloading. It is well to have a supply of compressed air where bulk cement is being used, regardless of the method of delivery into the bins. This air supply is used for fluffing up the cement after the cement in the bins has settled and packed. The introduction of a small amount of air into the bin or container has the effect of causing the cement to flow more easily through the various valves and gates and eliminates much of the arching action over the openings of the bins and containers. Care must be taken to keep the air free from excess moisture. The use of specially designed cement gates is strongly recommended properly to control the flow of cement and also to prevent loss of cement through leakage.

Bins for storage of bulk cement should be properly designed and well constructed and made water-proof and leak-proof. The use of lead strips and lead gaskets in all bolted and riveted steel connections of the bin proper is recommended. The angle of the bottom slope should not be less than 55 deg. Roof may be of wood or steel and must be made tight and with necessary openings for easy loading in accordance with the method of delivering cement to the top of bin.

Bucket elevators and screw conveyors where used, should be dust-proof and water-proof, and with properly designed openings for cleaning; and for the adjustment of bearings and for replacements when necessary. Electric motors should be properly enclosed and protected against the elements and made dust-proof as far as possible.

Provision for the storage of more than one kind of cement should be given serious consideration. Two or three compartments are generally desirable with the proper arrangement of gates and diversion spouts for delivery to the weighing hoppers. Note: Bag cement is also successfully used in conjunction with bulk cement or separately where conditions warrant.

CENTRAL MIXING PLANTS—AGITATOR OR NON-AGITATING TRUCK DELIVERY

Proportioning methods in general use for the operation of wet plants, are practically the same as in central proportioning plants designed for the operation of mixing in transit. The weighing batchers should be at least 50 per cent larger than for the maximum batch to be weighed. There are a number of methods of measuring by weight.

1. The use of a one, two or three beam scale with electrically controlled quick reading weighing device.

FIG. 2.—READY MIX AND SUPPLY CORP., ALBANY, N. Y.

2. One, two or three beam scales with indicator colored dial for quick reading purposes.

3. Large dial scale for weighing cumulative quantities, the various proportions being shown by indicators on the rim of the dial itself, and the total weight of all the materials representing the quantity in the batcher. The gates controlling the flow of the material into the weighing hopper are of two kinds—the sliding gate and the clamshell gate. The sliding gate is generally controlled by a rack and pinion arrangement with wheel controls, and the clamshell or radial gates are controlled with levers. It is important that the levers or wheel controls all be so arranged that the operator can control the various materials from one point on his platform. It is recommended cement not be weighed on aggregate material scales.

The tripping device for discharging the materials into the mixer are either of the direct trip or gate controlled discharge type.

The angle of the sides of the weighing hopper as well as the angle of the aggregate storage bin itself, should be of sufficient pitch so that the hoppers will be self-cleaning and not permit the arching of materials, which would necessitate pounding or hammering to accelerate the flow of material into the mixer. A 50 deg. angle is the flattest slope that is practical.

It is desirable that the size of the batchers be large enough to deliver a full batch to the size of the mixer used. The writer has observed in some plants the use of one yard batchers where a two or three yard mixer is being used. This necessitates two or three separate operations to measure one batch of concrete, with loss of time and economic inefficiency. There is also the possibility of error under such conditions.

Water tanks should be preferably of the automatic volumetric type or of the automatic weighing type. The automatic weighing type with electric controls is a practicable unit. There are a number of devices on the market that have been developed by various manufacturers for this operation.

The concrete mixers should be equipped with power discharge mechanism, within easy reach of the operator. They should also be equipped with a batchmeter and locking device such as is now in general use on paving mixers, so that the mixing time can be controlled properly.

The water pipe lines should be of sufficiently large size to permit rapid discharge of water into the mixer at the proper time. It is important that sufficient water enter the mixer to increase the mixing action and to prevent the building up of materials on the inside of the drum.

CENTRAL PROPORTIONING PLANTS—TRUCK MIXER DELIVERY

As previously stated, the operation of this plant is generally the same as that of the wet mix plant, with the exception that stationary mixers are not used, the material being charged into a truck body which mixes enroute.

THE COMBINATION PLANT

In this type of plant provision has been made for mixing at the plant and discharging into agitator type trucks, or proportioning for mixer trucks, or for dry batching materials for use in road pavers.

The general design of this type of plant is essentially as described above under "Wet Plants" but with by-pass arrangement controlled by the operator to divert the flow of materials into the central plant mixer, or directly into the truck mixer, or for loading batch trucks. The cost of the combination plant is very slightly more than that of the wet plant.

It is necessary to provide for heating the materials in the aggregate storage bin for cold weather operation. This is best done by live steam from a high pressure boiler with jets introduced into the lower section of the bin or with coils arranged inside the bin itself. The water used in mixing, must also be heated before passing through the water measuring tanks. The use of an auxiliary tank for heating and storing water is recommended to meet this requirement.

It is essential that devices be used in central proportioning plants to control the flow of materials so that the cement and various aggregates are fed uniformly into the opening of the truck mixer. This arrangement affords the advantage of a partial premix of the concrete materials and is a distinct advantage in the production of better concrete.

DELIVERY OF CONCRETE

Pre-Mixed Concrete, the Agitator, Semi-Agitator and Plain Trucks

After the sand, stone, cement, etc., have been deposited in the

mixer and been properly mixed, it is discharged into various types of agitating bodies.

1. The cylindrical drum type of agitator, is charged through a hatch at the top and the cylinder is revolved enroute to the job. This body is elevated or tilted by a standard truck hoist for the discharge of materials, through a rack and pinion tail gate. This unit is provided with an independent gasoline power plant for revolving the cylinder.

2. An open top agitating body has a central shaft with paddles attached. This type of truck is elevated by standard truck hoist to an angle of approximately 50 deg. and the discharge of concrete is by gravity and controlled by a rack and pinion tail gate. The agitation is controlled by power take-off gear arrangement from the truck engine.

3. A cylindrical type of body has blades on the inside either of the bucket type or of screw conveyor type, by which the material is propelled to the rear of the truck and discharged through rear control door. These units have an independent power plant for revolving the body. They require no hoist.

4. From another type the material is discharged from the bottom of a cylindrical body onto a pan where it flows by gravity to the rear of the truck.

5. A bathtub type of open top body has no agitator equipment of any kind, and the concrete is discharged in much the same manner as from the ordinary material dump truck.

6. The remixing type of open top body is intended to give a partial remixing action of the concrete when the body is tilted and discharged. This unit also has rear end control gate with rack and pinion arrangement.

7. Finally, there is the plain open-top, dump-truck body with truck-hoist and rear control, tail gates.

It is highly important that the concrete mixer be of the same capacity as the capacity of the delivery unit. This eliminates lost time and makes for general efficiency in the operation of the plant.

Truck Mixers

The equipment for this type of plant is practically the same as for wet mix plants, but with the addition of special loading devices designed to meet the requirements of the type of mixer truck

that is being used. Three types of truck mixers now in general use are as follows:

1. One type is a cylindrical body operated through a power take-off and gear drive from the engine of the truck. In this unit the material is charged into the cone-shaped body through an opening at the rear, and the proper amount of water added while mixing, enroute to the point of final deposit or after the truck arrives at the job. The water is measured at the plant and deposited into a tank having two compartments, one which contains the measured amount of water for the mixing of the concrete proper and the second smaller compartment which contains a small amount of water used in washing the truck out on its return trip.

The discharge of the concrete from this type of body is effected by the tilting of the body through a mechanical type truck hoist, the body revolving while discharging. While the truck is enroute to the job, the opening at the end of the drum is covered with a removable door to prevent leakage or loss of material.

2. Another type of truck mixer has a drum with a series of buckets and blades, and a discharge chute. This truck is charged at the plant through an opening in the top of the drum and the cover is then closed. Operation of the drum is by an auxiliary gasoline engine operating through a series of clutches to reverse the action of the mixing drum, for the purpose of mixing or discharging. This unit is equipped with a water tank properly calibrated, and the amount of water is added by the operator of the truck, in accordance with the required specifications. This tank has two compartments, one for mixing water and one for flushing or cleaning water.

The discharge of the concrete in this unit is effected by the removal of the cylindrical cover at the rear of the drum, and the introduction of a discharge chute similar to that used in the regular drum type concrete mixer.

3. Another truck mixer unit is also designed to be loaded through a removable cover at the top of the drum. This cover is closed when the unit has been loaded and the material is then mixed by rotating the drum. When the unit arrives at its destination, it is revolved in the opposite direction, thereby bringing the

material to the rear and discharging it through a cylindrical gate with wheel control.

This unit is also equipped with a calibrated water tank, the water being added by the operator of the truck to meet the required specifications. This design of truck unit with the interior blading arrangement similar to the screw conveyor, is equipped with an independent power plant and also with a power takeoff from the truck motor itself, with a series of properly designed reduction gears.

All of the above type agitator bodies and mixing truck bodies are built in sizes of one-to six-cu. yd. capacity and are generally mounted on trucks designed to carry the necessary loads. They are equipped with pneumatic tires and solid rubber tires, to meet local conditions.

There are various types of trucks now in use for this purpose, ranging from the regular four wheel trucks to the six wheel trucks, and the four wheel trailers.

The number of truck units necessary for the proper operation of the plant is determined entirely by the amount of concrete to be delivered and the length of haul. In some cases, a number of producers of ready mixed concrete have combined their operations in a manner that permits the transfer of a number of trucks from one plant to another, so as to take advantage of peak load requirements. This has worked economically in a number of instances.

MISCELLANEOUS PROBLEMS

In some plants individual problems have been solved by the ingenuity of the operators in devising special equipment and methods to meet the particular requirements of their local conditions, and it is safe to state that a majority of present plants are operating successfully but probably do not represent the ultimate development in plant equipment, plant control, or hauling and placing methods.

It is strongly advised that proper engineering control be set up covering all of the factors entering into the manufacture and delivery of central plant concrete. This should include proper inspection and testing service. Facilities should include the determination of proper concrete aggregates and their inspection. Suitable equipment should be provided at the plant for determining the moisture content of the fine and coarse aggregates,

and tests of this condition shall be made a number of times each day. Suitable engineering service should be available for the proper design of the various concrete mixtures required. Provision should be made for frequent inspection of all the measuring equipment used in the plant to insure constant accuracy.

There are a number of methods in use at the various plants throughout the country for records of maintenance costs, methods of keeping material receipts, delivery receipts, etc., all of which this Committee is assembling for a future report.

It is also desirable in all of these plants that contact be maintained between the office and the operator. This is best done through the use of a pneumatic system or some form of electric signal for delivering messages. The use of a telephone on the platform particularly in a wet mixed plant is not generally efficient, because of the noises from the mixer, motor, etc., which interfere with the clear hearing of the operator and result in misunderstandings. There are electric light systems that are used in some localities which have been effective in transmitting information from the office to the operator.

It is suggested that a machine shop be maintained at every plant where repair parts and replacements are carried for the truck equipment, and where necessary replacement items shall be kept on hand in case of wear or breakdown of any part of the plant itself. A few extra parts such as gears, chain, fuses, etc., will save their cost many times in the course of a year, by preventing shutdowns in the plant operation.

This report obviously is not complete but is intended to stimulate interest and discussion. There is in the hands of the Committee a considerable amount of detailed information in an incomplete state, which we will endeavor to compile and report on as rapidly as possible. Much research work is now being done along constructive lines and additional data on the subject will be submitted to the Institute in a later report.

Readers are referred to the JOURNAL *for December 1931 (Vol. 28), for discussion which may develop. Such discussion should reach the Secretary by Nov. 1, 1931.*

Specification for Concrete Burial Vaults

*Progress Report of Committee 709**

W. D. M. ALLAN, CHAIRMAN

INTRODUCTION

November 12, 1930, Wilber M. Krieger, executive secretary of the National Selected Morticians, wrote the secretary requesting that the American Concrete Institute prepare a specification which could be used to measure the quality of concrete burial vaults. At the same time Mr. Krieger wrote H. A. Ledyard, president of the National Concrete Burial Vault Association, outlining the value of a specification prepared by a national technical organization in extending the use of this product.

Department of Commerce reports show that the output of concrete vaults for 1929 was approximately 80,000 but members of the committee believe that actual production is nearer 125,000. The total vault business available for all types and materials is about one million per year. Even though the vault field is far removed from ordinary concrete work the satisfactory performance of the finished product depends upon the quality of concrete used. It is therefore proper that the Institute recognize the problem and comply with the request to develop, if possible, a satisfactory specification.

Attention has been directed by many vaults of poor quality and by the advertising of competitive types of vaults to the necessity for a standard specification. This led to the formation of Committee 709.

For nearly two years the National Concrete Burial Vault Association has had under consideration a specification for con-

*Presented at the 27th Annual Convention, A. C. I., Milwaukee, Feb. 24-26, 1931 by C. A. Wiepking, Testing Engineer, Milwaukee, Wis., member of the Committee. Other members of the Committee are: C. L. Berg, R. F. Hanneman, Prof. Carl Head, H. A. Ledyard, F. J. Mead, George M. Painter, H. G. Samson, J. H. Stuart and F. H. Van Ness.

crete vaults. Data collected by their research committee has been turned over to this committee.

In order to understand the quality of concrete required to make a satisfactory vault, it was necessary to study the problem from the standpoint of the funeral director, the cemetery superintendent and the manufacturer. The funeral director requires that the concrete be watertight, durable, strong, and dense enough to resist attacks of chemicals in ground waters. The cemetery superintendent demands the same factors but is especially interested in strength requirements which will eliminate sunken graves. The manufacturer requires a container of minimum weight that will meet the purchaser's requirements and which can be manufactured at a cost to compete with other types of vaults. The specification must cover all of these points and still be simple and easy to enforce.

Time has not been available since the formation of the Committee Jan. 20, 1931, to present a Tentative Specification. The Committee believes that this report should be on record so that discussion can be drawn from morticians and vault manufacturers on the provisions of the specification and the possibility of enforcement.

SUGGESTED SPECIFICATION FOR CONCRETE BURIAL VAULTS

1. GENERAL

Scope

1. This specification applies to reinforced concrete vaults, intended for use as burial receptacles, made in two pieces; a base and cover.

Basis of Acceptance

2. The acceptability of vaults shall be determined by the results of the strength, absorption and hydrostatic tests herein after specified, and by visual inspection.

Discussion—For well established plants with rigid methods of control, it is suggested that visual inspection and strength and absorption tests on cylinders should be sufficient to insure the quality of the vault, providing the purchaser is satisfied with methods for sealing at the grave.

2. MATERIALS

Reinforced Concrete

3. The reinforced concrete shall consist of portland cement, mineral aggregate and water in which steel reinforcement has been embedded.

Cement

4. Portland cement shall meet the requirements of the current Standard Specifications and Tests for Portland Cement of the American Society for Testing Materials.

Steel

5. Reinforcement shall consist of wire which meets the requirements of the current Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement of the American Society for Testing Materials, or of bars which meet the requirements of the current Standard Specifications for Billet-Steel Concrete Reinforcement Bars of the American Society for Testing Materials.

Aggregates

(a) Fine aggregate shall consist of sand, stone or slag screenings, or other inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, durable, uncoated grains and free from injurious amounts of dust, lumps, soft or flaky particles, shale, alkali, organic matter, loam or other deleterious substances. Fine aggregate shall be well graded and shall pass a ¼-in. screen. At least 5 and not more than 20 per cent shall pass a 50 mesh screen and at least 10 and not more than 20 per cent shall be retained on a No. 8 screen.

(b) Coarse aggregate shall consist of crushed stone, gravel, slag, or other approved inert materials with similar characteristics, or combinations thereof, having clean, hard, strong, durable, uncoated particles, free from injurious amounts of soft, friable, thin, elongated or laminated pieces, alkali, organic or other deleterious matter. All of the coarse aggregate shall pass a ⅜-in. screen and be retained on a ⅛-in. screen.

3. DESIGN

Minimum Design

9. The vaults shall be designed in accordance with the following assumptions:

(a) That the design load is equivalent to the vertical load uniformly distributed over the internal horizontal cross-sectional area of the vault and that the vault is likewise uniformly supported.

(b) The distance from the center of the reinforcement to the nearest surface of the concrete shall not be less than (. . . .) in.

Discussion—This dimension has been left blank because it depends upon the minimum thickness of vaults permitted. In general only one line of reinforcement is used so that this distance should be one-half the minimum thickness of vault decided upon.

(c) The shell thickness of the vault shall not be less than (. . . .) in.

Discussion—The shell thickness finally decided upon must consider the manufacturer's demand for minimum weight, yet provide for adequate protection for reinforcement and resistance to normal earth and water pressures. The Committee has not determined as yet whether this should be one inch, one and one-half inches or two inches.

(d) The minimum weight of reinforcement shall be equal to (. . . .) lb. per 100 sq. ft. of vault wall area and if of mesh shall have openings at least (. . . .) in. square.

Discussion—The average weight of reinforcement now used is approximately 50 lb. per 100 sq. ft. but individual manufacturers vary widely from this average. The opening in mesh must be large enough to permit the concrete to pass freely through and embed the individual members. The larger mesh also permits the use of heavier wires, is easier to handle and is frequently more economical. A minimum size opening 2 in. square and a maximum of 6 in. square are being considered.

(e) The net quantity of mixing water in the concrete mixture, including the surface water carried by the aggregate shall not exceed (. . . .) gal. per sack (94 lb. net) of cement. The proportions of aggregates to cement shall be such as produce concrete that will work readily in the form and around reinforcement without excessive puddling or spading and without permitting the materials to segregate or free water to collect on the surface. The slump of this concrete when measured according to the current Method of Test for Consistency of Portland Cement Concrete of the American Society for Testing Materials shall be not more than (. . . .) in.

Discussion—Experiments conducted over a period of two years at the Portland Cement Association Laboratory show that in thin sections (1 to 2 in.) with 7 days moist curing not more than 5 gallons of mixing water net should be used per sack of cement to produce concrete of unquestioned watertightness. The suggested maximum slump 4 to 5 in. is being considered to prevent segregation of aggregates and the tendency to form water pockets.

Placing Reinforcement

12. When a single line of reinforcement is used, it shall be placed in the center of the wall. The reinforcement shall be lapped not less than 30 diameters if of bars or 2 openings if of

mesh and securely tied with No. 18 annealed wire, or if welded the joints shall develop the full strength of the reinforcement.

4. WORKMANSHIP AND FINISH

Finish of Concrete

13. Vaults shall be smooth, free from stone, air or water pockets and structural cracks.

5. MARKINGS

Markings

14. All vaults made in accordance with this specification shall be marked as follows:

a. Meets current A. C. I. Specification

b. The name or identifying mark of manufacturer

6. PHYSICAL TESTS

Concrete Tests

15. The quality of concrete shall be determined by compression and absorption tests on 3 by 6-in. cylinders taken from the concrete used in making the vaults and manufactured and cured under identical conditions with the vaults.

Compression Tests

(a) When tested in accordance with the current standard methods prescribed by the American Society for Testing Materials, these cylinders shall have a strength of not less than (. . . .) lb. per sq. in. when 28 days old or when the vaults are delivered, if delivered in less than 28 days.

Discussion—The strength requirement has been usually considered as 4,000 lb. per sq. in., but since watertightness is a major factor in producing satisfactory vaults, it may be that in order to get the degree of watertightness necessary, the strength will be automatically increased to 5,000 or 6,000 lb. per sq. in. A higher compressive strength is also necessary if the thinner walls suggested in this report are adopted.

Absorption Tests

(a) At least three 3 by 6-in. cylinders in addition to those submitted for the compression test shall be furnished for the absorption test. The specimens shall be indelibly marked, to identify them with the vaults made with the same batches of concrete and cured in the same manner as the vaults.

(b) Specimens shall be dried at a temperature of from 100° to 110° C. (212° to 230° F.) for 24 hours.

Discussion—Laboratory tests show that 3 by 6-in. cylinders made of 5 gallon concrete and saturated at the beginning of the test will lose within 1.25 per cent of its total loss in weight with 24 hours drying at the temperatures specified. Since it will be only in prolonged rainy seasons in the case of vaults stored in the open that the specimen will be saturated, the 24-hour drying is considered sufficient. This is especially true, since the loss on drying at these temperatures for 24 hours will cause the concrete to lose more water than it would under any usual atmospheric condition. By decreasing the absorption requirement one per cent, the test for 24 hours can be corrected to equal complete drying.

(c) The dried specimens shall be placed in a suitable receptacle, covered with distilled water or rain water at room temperature (70 deg. F.) for 24 hours. After this immersion period, the specimens shall be removed from the water, allowed to drain for not more than one minute, the superficial water removed by a towel or blotting paper, and the specimen immediately weighed.

(d) The balance used shall be sensitive to 0.5 gr. when loaded with 1 kg. and weighings shall be read at least to the nearest gram. Where other than metric weights are used, the same degree of accuracy must be obtained.

(e) The increase in weight of the immersed specimen over its dry weight shall be considered the absorption of the specimen and shall be calculated as a percentage of the dry weight by the following formula:

$$\text{Percentage absorption} = 100\,\frac{\text{weight wet} - \text{weight dried}}{\text{weight dried}}.$$ The results shall be reported separately for each specimen.

(f) The average absorption shall not exceed (....) per cent for three (3) test specimens with no one specimen testing more than (....) per cent.

Discussion—It has been suggested that the average absorption limit should be placed at 3 or 5 per cent with no one specimen testing more than one per cent above the average agreed on.

Strength Test on Vaults

16. Vaults shall be tested with a load applied on top equal to (....) lb. per sq. ft. of inside horizontal cross-sectional area.

(a) The vault shall be set on a uniform bed of moist sand of such size that all of the particles will pass a ¼-in. screen.

(b) The top bearing frame shall not be allowed to come in contact with the top bearing plate. The upper surface of the sand

in the top bearing frame shall be struck level with a straight edge, and shall be covered with a rigid top bearing plate, with lower surface a true plane, made of heavy timbers or other rigid material, capable of distributing the test load uniformly without appreciable bending. The test load shall be applied uniformly over the top of the vault. (See Fig. 1.)

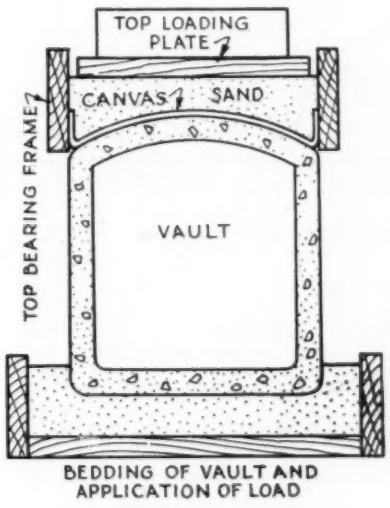

FIG. 1—SAND BEARING FOR COMPRESSION TEST ON CONCRETE BURIAL VAULTS

(c) The top and bottom bearing frames shall be made of timbers heavy enough to avoid appreciable bending by the side pressure of sand. The interior surfaces of the frames shall be dressed.

Discussion—The maximum puddled earth load on the vault in service is approximately 390 lbs. per sq. ft. of inside horizontal cross-sectional area but the committee believes that the test load should be increased to provide a factor of safety. Five hundred to six hundred lbs. per sq. ft. have been suggested. Field tests of vaults made under this specification will be made to determine what this load should be.

By using slabs of concrete having a combined weight equal to the required load minus the weight of the upper frame, sand and bearing plate, the test may be made very quickly on each vault sold or as required. Hydraulic jacks set up in rigid structural steel frames may also be used. (See Fig. 2.)

(d) After the load has remained on the vault one hour it shall be removed and the specimen inspected. The vault shall have failed if any visible structural cracks have developed during the test.

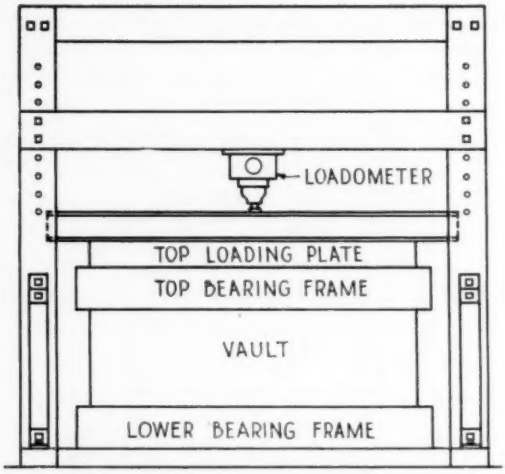

FIG. 2—SAND BEARING WITH LOAD APPLIED BY HYDRAULIC JACK

(e) At least one loading test must be made by the manufacturer each month but the purchaser may require one test be made for each (. . . .) vaults purchased.

Discussion—The strength of the test cylinders are a close indication of the strength of the vault manufactured according to this specification, and it is recommended that the purchaser accept the results of the single vault test made each month by the manufacturer together with the compression and absorption tests on cylinders as a measure of the vault strength. The suggestion has been made by some, that the purchaser be permitted to require one loading test for each ten vaults purchased.

(f) All vaults for testing purposes shall be selected at random by the purchaser or his representative from the stock of the manufacturer and shall be vaults which would not otherwise be rejected under this specification.

Hydrostatic Test

17.

Discussion—The method of making the hydrostatic test has not been developed to a point where agreement is possible. A concrete pit six feet deep in which the vault may be submerged and held down by a suitable weight or

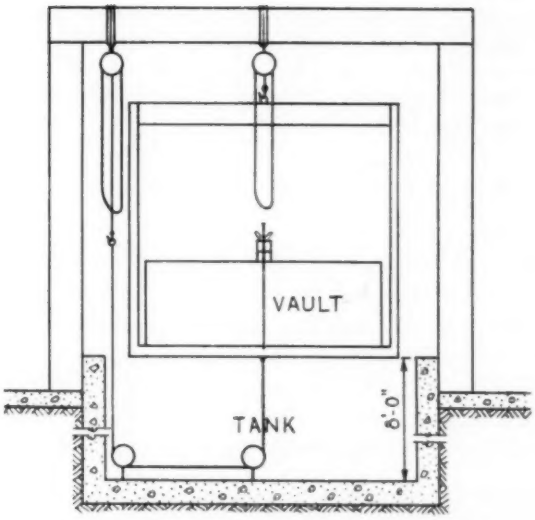

FIG. 3—HYDROSTATIC TEST BY SUBMERSION

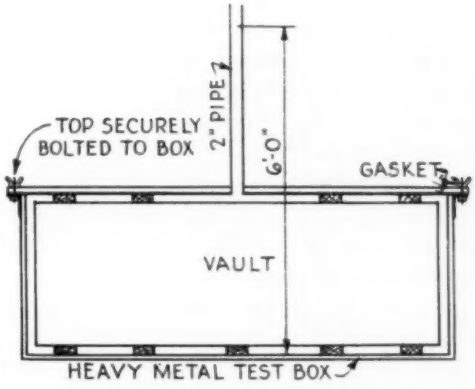

FIG. 4—HYDROSTATIC TEST BY PRESSURE BOX

system of winches has been used by a number of manufacturers. A rigid container equipped with a standpipe of suitable height in which the vault could be placed has the advantage of simplicity. A disc of suitable area, equipped with a two-inch standpipe, which could be fastened to the side of the vault is relatively cheap and easy to apply but has the disadvantage of not testing the entire vault including the seal. Discussion on this test will be particularly welcomed. (See Figs. 3, 4, 5.)

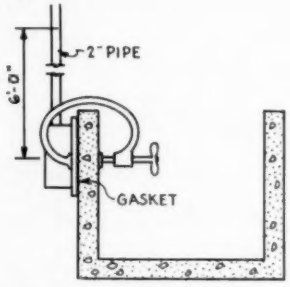

FIG. 5—HYDROSTATIC TEST ON SMALL AREA

Minimum Age for Shipment

18. Vaults will be considered ready for shipment when 28 days old, or when cylinder tests indicate that the concrete has attained the strength required.

7. SEALING

Materials and Methods

19.

Discussion—The Committee has not had sufficient time to investigate this subject and welcomes discussion by all interested parties. It has not, however, been definitely decided that this subject should be included directly in the specification. It will, of course, be included indirectly by the hydrostatic test.

8. INSPECTION

20. All materials, processes of manufacture and finished vaults shall be subject to inspection and approval by the purchaser or his representative.

21. Vaults shall be subject to rejection on account of the failure to meet any of the specification requirements.

END OF SPECIFICATION

The Committee presents its report in a form intended to create discussion and invites manufacturers, purchasers and interested engineers to review these requirements and submit their discussions.

Readers are referred to the JOURNAL *for Dec. 1931 (Vol. 28), for discussion which may develop. Such discussion should reach the Secretary by Nov. 1.*

Discussion of Report of Committee 203

"Cinders as Concrete Aggregate"*

CONVENTION PRESENTATION BY EINAR CHRISTENSEN, AUTHOR-CHAIRMAN

It makes me very happy that the American Concrete Institute has set aside this session for some of the problems of light weight concrete. It indicates that we are now in a position to spend some time on matters not pertaining to the dams and the beams and the arches and the roads that consume nine-tenths or more of our good cement—and can begin to consider the field beyond, which at present is small but which I believe will be of increasingly great importance.

Light weight concrete has been with us for some time—and I do not think anyone will question that it is here to stay. Whether the ultimate light weight aggregate is cinders (as they can be, and as I expect to see them prepared), or it is Haydite or some other natural or artificial cellular material, is something I do not know. Purpose, quality and economy must be considered. But I think that the lines of development have been laid out.

It should not be presumptuous to say that the cinder concrete industry took the early lead. It was through study of cinder concrete that we discovered that concrete might have other attributes besides those of strength and density. We began to hear about lightness, insulation, nailability, etc. I am not much wrong when I say that cinder concrete has been the step-child of the concrete industry. In saying that, I am not complaining. It is only during the last ten or twenty years that we have gotten down to fundamentals of rational design of stone concrete—and that has naturally and rightly kept the Institute busy.

*A. C. I. Journal, Feb. 1931; *Proceedings*, Vol. 27, p. 583. Mr. Christensen as Author-Chairman of the Committee made a presentation of the report at the 27th Annual Convention, Milwaukee, Feb. 24-26, 1931. Critic members of the Committee are: W. D. M. Allan, R. D. Bradbury, Miles N. Clair, Emil Praeger, M. J. Roach. The discussion here is incomplete and will be concluded in the December, 1931, Journal, Vol. 28.

It is my conviction that time is now ripe for a survey of our knowledge of cinders as an aggregate for concrete. The grand objection to cinder concrete has been that the material could not be put on a basis of rational design—but this is no longer true of factory-made cinder concrete, and it need not be true of job-made concrete. Perhaps we know a little more about the subject than some members think. It was to find out how much we know that Committee 203 was appointed.

It was really a big assignment—to cover the whole field from red hot cinders on the grate to the calm and presumably contented concrete in the structure. The result is in the February JOURNAL. As an easily read paper the report suffers from being much too long—as a comprehensive report it suffers by being much too short. Brevity is likely to be attained at the expense of some accuracy, which is most unfortunate, and it frequently leads to a confusion of opinion and fully established fact. How far we have avoided that in the report is something I cannot fully judge.

In reading the report, you will probably miss that favorite statement of many authors, that "more research is needed here, there and everywhere." I did not find it necessary to say that over and over again—the need for more research should be apparent to every reader. I also hope that the report shows that such research is not only needed but appears justified and deserved by what may be accomplished. I shall feel very much disappointed indeed if some of the opinions advanced in the report are not disproven or altered within the next ten years. But if the report can bring about such learning of new facts, then it has accomplished its main purpose.

In giving a brief synopsis of the paper I realize the difficulty of condensing these sixty-odd pages into ten minutes—particularly when considering the fact that the whole report as it now appears was a matter of considerable condensing. But I shall try.

Synopsis

Certain definitions are used throughout the report. For example, the term "Cinder Concrete" is applied only to a concrete made with an aggregate of nothing but cinders, while the term "Sand-Cinder Concrete" is applied to the type of concrete in which the aggregate is composed of both sand and cinders. "Cinders" is differentiated from "Ashes"—the former term applying to the residue from high temperature combustion of coal or coke, while the latter

applies as a more inclusive term, to all residues from the incomplete combustion of carbonaceous matter.

No differentiation is made between anthracite and bituminous cinders. While they differ in their physical character, they are both suitable for concrete when meeting the requirements here proposed for the raw material.

Cinders—The constituents of cinders affecting the value of the material as an aggregate for concrete are coal, coke, sulphates, sulphides, and (perhaps) lime.

The effect of combustible matter on fire resistance is surprisingly small. The Underwriters' Laboratories, in their present specifications for hollow concrete building units, state: "When cinders are used the average combustible content of the mixed fine and coarse aggregate shall not exceed 35 per cent by weight of the dry mixed aggregates." Bituminous coal of a certain character (having high absorptive power) may cause expansional movement during the early life of the concrete. A soundness test is described.

Cinders usually contain a small amount of sulphur compounds (sulphates, sulphides, etc.). Corrosion of steel in cinder concrete occurs only when the concrete is of such poor quality that air and moisture readily get into contact with the steel. Under the same conditions, corrosion will occur in concretes made with any type of aggregate. It is possible that in such concrete the corrosion of the unprotected steel will be accelerated by the presence of sulphates and the like in solution, but it is absurd to ascribe any effect as due to "oxidation of sulphides to sulphuric acid." The uniformly successful record of sand-cinder concrete in New York, as far as protection of steel is concerned, cannot be ignored.

Specification for Cinders—A specification for cinders should be liberal enough to be practical; otherwise it is not enforced. Based on this idea the report proposes a specification simply calling for cinders (not ashes) from high temperature combustion, well burned, free from foreign matter and so graded as to produce a cinder concrete meeting the strength requirements of the building code. Based on certain tests, limits for combustible matter and sulphur compounds are proposed.

Judging Cinders for Concrete—Judgment is still an important factor in making concrete, and when cinders are used as an aggregate it is well to have some simple rules for judging the material without having to resort to elaborate physical and chemical tests.

The report proposes certain rules. First, something should be found out about the source of supply; frequently records are kept there of analysis of cinders. Second, if the cinders contain rubbish they should not be used because the pile may have been a general dump and the cinders may contain dangerous impurities. Cinders from a chemical plant, it may be well to test with a water extract (boiled with distilled water) with litmus paper; the paper should turn slightly blue. Third, representative sample of the cinders should be dumped into a bucket filled with water; the fine ash and the lighter coke will float and the amount and nature of these may be judged. After draining the water from the bucket the appearance of the washed cinders should be compared with

that of the unwashed; the knowledge is gained of the relative amount of coke, coal, fines, porous, flaky, or fully vitrified clinker; the grading may be observed. Fourth, the strength of the larger particles may be judged by breaking them down. The weight per cubic foot should be determined.

The use of the bucket and the other simple methods proposed may appear very crude to the engineer—nevertheless, such simple methods have been found very useful, when used with some experience and common sense.

Testing Cinders for Concrete—When it is a matter of selecting a large and steady supply of cinders, a definite effort should be made to obtain the raw material from one known and reliable source. The cinders should then be subjected to more exhaustive tests, over enough time to determine average quality.

The tests should include determination of combustible content, nature of coal, soundness test of coal if bituminous, examination for impurities, sieve analysis, etc.

Making Cinder Concrete Building Units—The typical unit of the cinder unit industry is the 8 x 8 x 16 in. hollow block, containing two or three hollow cores, or from 30 to 40 per cent hollow space. Most specifications require this unit to have a compressive strength, at 28 days, of 700 lbs. per square inch of gross area.

Strength is not the sole criterion for quality of cinder concrete; the cellular structure should be developed in order to obtain such characteristics as lightness, insulation, nailability, etc. The resulting concrete should be considered within its own field, not as a general substitute for stone concrete.

Maximum size of aggregate is generally limited to ½ to ¾ in. Most desirable grading appears to be represented by a fineness modulus of 4.0 to 4.5 (maximum size ¾ in.). A simple rule suggests that the aggregate "split" 50-50 or 40-60 on ¼ in. sieve, assuming usual range from coarse to fine as found in crushed but unscreened cinders.

The voids of loosely packed aggregate appear to average about 55 per cent, with from 8 to 16 per cent inaccessible, sealed cells. A large amount of moisture is generally present in raw cinders when received. Damp volume is greater than dry volume, a bulking of about 25 per cent having been recorded, fairly constant within wide range.

Cinder concrete masonry units are made from a relatively dry mix, under pressure. It is well to bear this in mind when comparing the material with job-poured concrete; while machine made cinder concrete lacks plasticity, it is placed in such a way that homogeneity and the necessary density may well be obtained. Total mixing water necessary depends upon material and conditions. Tests are recorded representing best results at 1.5 to 1.8 gallons of water per cubic foot of aggregate (for 1:7 to 1:10 mix).

Open stationary-drum mixers are used. Conveyers for cinders are designed to minimize abrasive effect of material. Crushers of the jaw-type, slow-hammer type, or rolls are used in primary reduction; rolls are best for secondary reduction. Grading of cinders, while highly desirable, is at best an incomplete operation due to dampness of cinders and shape of particles. Only fast vibrat-

ing screens are suitable. It is important to prevent segregation of aggregate; this is attained by having storage bins of small diameter, keeping them full, or by dumping cinders in bulk.

Making Sand-Cinder Concrete—Sand-cinder concrete should be designed for the purpose for which it is used, and not according to arbitrary specifications like the "1:2:5" so frequently encountered. The main reason for the use of cinders in this type of concrete (structural concrete) is the lightness of the aggregate. The main reason for the addition of sand is to produce workability.

Tests indicate that blindly adding sand does not of necessity increase the strength or improve the quality of sand-cinder concrete; the grading of the combined aggregates must be considered. High uniform strength tests are reported on 1:2:5 and 1:2:4 sand-cinder concretes where the cinders had a fineness modulus of about 5.7, the sand about 2.4, and the mixed aggregates about 4.65.

In the same series of tests the total volume of mixing water (including that present in the damp cinders when received) measured about 13 to 14 gallons per sack of cement for the 1:2:5 mix and about 11 to 12 gallons for the 1:2:4 mix. The concrete was used in casting reinforced beams.

Recent tests indicate that cinder concrete without sand may give excellent results for structural purposes.

It is believed that there should be a considerable market for a prepared cinder, crushed and graded, and properly mixed with sand if necessary, to meet definite requirements. This may be the only way in which rationally designed mixtures may be obtained for structural purposes.

Characteristics of Resulting Concrete—The usual strength requirement for cinder concrete building units (hollow) is 700 lbs. per square inch of gross area. The compressive strength of standard 8 x 16 in. cylinders of good New York sand-cinder concrete is reported to be 800 to 1,000 lbs. per square inch at 28 days (1:2:5 mix), the modulus of elasticity is about 1,200,000 lbs. per square inch. Much higher results are obtained under conditions of better control than that usually found on jobs at present.

The average weight of cinder concrete, as used in the cinder unit industry, appears to be about 85 to 90 lbs. per cubic foot. 1:2:5 sand-cinder concrete (structural concrete) averages about 110 to 115 lbs. per cubic foot.

When comparing absorption percentages with those of stone concrete and other heavier building materials, consideration should be given to the lightness of cinder and sand-cinder concrete. The significance of the usual absorption test is questioned. The test does not seem to give information regarding resistance to weather and freezing, capillary behavior, etc. The shape, size and distribution of pores should be studied.

The fire resistance of well made cinder and sand-cinder concrete appears well established. The behavior under exposure to fire and water is remarkable; the heat transfer is low when the cellular structure is properly controlled.

Data on cinder concrete (as used in making cinder units) indicate the Coefficient of Conductivity "K" to be 3.33 (per inch thickness). For usual

conditions, an 8 in. hollow cinder block wall (exposed) will have a Conductance (C) of 0.45 or less, and a Transmittance (U) of about 0.34.

Exposed surfaces of cinder concrete appear to have a very high sound absorption. The sound transmission through properly constructed walls of cinder concrete appears low. As with heat transmission, the cellular structure is the determining factor.

Properly made cinder concrete will receive and hold nails, and woodwork is nearly always nailed direct to the masonry wall. Machine made (relatively dry mix) cinder concrete building units have an interesting surface texture offering remarkable adhesion for plaster, mortar and the like.

Such is our report on an aggregate that some able engineers use to the extent of millions of cubic yards, while other able engineers flatly condemn it. They did not wait for this review to build the Empire State Building, the Chrysler Building or all the other buildings that have given New York its vertical growth, and in which so many thousand yards of cinders were used. I don't think the report will make them regret it. Rather, I hope the report will lead to an increasing and an increasingly intelligent use of cinders as an aggregate for concrete.

In getting up the report I have received great help from the members appointed on Committee 203. In this respect I am probably much more fortunate than some other author chairmen—and I am very grateful.

WRITTEN DISCUSSION

BY GEORGE E. STREHAN*

The author's proposed definitions of "cinder concrete" and "sand-cinder concrete" are not in line with engineering practice and in the writer's opinion are misleading. Portland cement concretes are generally designated as "stone concrete," "slag concrete," "gravel concrete," etc., as determined by the coarse aggregate. The discussion advanced in the report does not warrant a change from this practice. In the writer's opinion, what Mr. Christensen refers to as cinder concrete in the "factory-made cinder unit" of today is not well-made cinder concrete at all. Plasticity, workability and durability are generally required essentials of good concrete. Plasticity depends upon the presence of a sufficient quantity of plastic paste to form a homogeneous

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mixture with the coarse aggregate; workability determines the ease of combining and placing the mixture without excessive voids, honeycombing or segregation; and durability in concrete construction exposed directly or indirectly to the elements is in large measure dependent upon the absence of porous or cellular structure.

The two controversial features connected with the use of cinder concrete, whether in the form of precast shop-made units or monolithic, poured-in-place concrete are: (1) corrosion of reinforcement; and (2) durability. The writer would dismiss all discussion of the fire resistance of cinder concrete as having been demonstrated without a margin of doubt both in practice and laboratory experience. The controversies as regards corrosion of embedded steel and the permanence of cinder concrete are however, exceedingly live subjects; and are due to the *misuse* of cinder concrete rather than to any inherent defect of the material itself. The author refers to the excellent behavior of the cinder concrete construction in Professor Woolson's test house erected in 1905 at Greenpoint, Brooklyn, which is still doing duty as a test furnace after some 300 to 400 hours of 1700 deg. F. fire. The walls of this structure were made of a 1:2:5 plastic mix of sand, cement and steam boiler plant cinders quite different from the concrete generally employed for cinder block units.

Mr. Christensen speaks with authority on the subject of the shop-made cinder building unit. He is concise and thorough on the subject of selection of proper cinders for pre-cast units. His seven rules of procedure to determine the quality of cinders for use as an aggregate should provide a good measure of the quality of the material for aggregate purposes in present day practice. The requirements of practical value are maximum permissible combustible content in the cinders (now fixed by the Underwriters at 35 per cent), and minimum concrete strength requirements for use of the unit for either load bearing or non-load bearing purposes. The discussion of the manufacture of cinder units is thorough in detail and presents an ideal for the industry. The fact remains however that to the average block-plant, cinders that can be bought for 50 cents a yard are vastly more attractive than cinders costing $1.40 a yard for fixed grading and correct chemical composition. One very important considera-

tion is not stressed sufficiently by the author. The machine-tamped cinder concrete unit is made of a relatively dry, non-plastic mixture. Sufficient water cannot be added to the mixture for complete hydration without encountering the possibility of slumping of the block. The curing conditions prevailing in most cinder concrete products plants are not conducive to complete hydration. Accelerated or steam curing is seldom resorted to. A liberal use of calcium chloride is a frequent substitute used to accelerate setting. The author states that "Because of the porosity of the cinder aggregates, a large water reserve is available for hydration of the cement, and because of the nature of the concrete, the water is slow in reaching the surface where it evaporates." This is contrary to the writer's experience. Because of the physical characteristics of the aggregate, the excess water in the block has a tendency to rapid drainage.

It is known that well-made plastic concrete deposited on the interior of a building exposed to extreme dry heat will lose strength in time, through the arrested process of hydration caused by the absence of the necessary moisture content. It is the writer's belief that very little study is given to the control of water content in the average cinder unit plant; and frequently the only water used in manufacture is the water contained in the cinder aggregate as stored amounting perhaps to 4 or 5 lbs. of water per cubic foot. The uncured cinder unit placed in the wall continues to hydrate for a considerable period beyond the conventional 28 days, accompanied by volumetric changes that are always incident to this continued "working." This process plus the cellular character of the block unit, in the writer's opinion, accounts for much of the lack of durability or permanence in the structure as well as the corrosion of embedded steel occasionally demonstrated by the rusting of nails driven into the masonry. Moisture absorption is particularly large in cinder mortars and in masonry walls, the cinder concrete building unit is not fully protected against the moisture forced in from the outside. The ultimate curing and hydration of the cement content in the block is dependent on the acquisition of this moisture. The high expansional movement of cinder concrete normally associated with its early life is very likely to be prolonged to the

masonry in the wall because of the slow hydration of an all-cinder concrete mixture.

The second sub-division of the paper dealing with the practices and uses of "sand-cinder concrete," has failed to emphasize some of the true significance of cinder concrete proper, particularly as it relates to New York experience. From 1896, when this type of construction first received recognition in New York City, after full-size fire and load test investigations by the New York Bureau of Buildings, until 1915, the industry has been continually experimenting with various proportions of sand and cinders and of cinders alone in combination with portland cement. Much of this research was done prior to the publication of the "water-cement ratio" and the "fineness-modulus" theories. Nevertheless the development of the 1:2:5 sand-cinder mix is not an arbitrary choice. It was arrived at by the same methods as the 1:7 and the 1:9 cinder mixes of the block industry; and proved its effectiveness as a fire-resistive concrete of sufficient strength and density combined with relatively light weight. It was found that the run of commercial cinders resulting from forced draft burning is generally deficient in fine material and that the cinder fines are of such nature as to resist combination with the cement and water. In a batch, the mixture results in a harsh, unworkable concrete. Some of the earlier approvals granted by the City of New York included mixtures of 1 cement to 5 or 7 cinders. In general, however, these harsh mixes have been abandoned. Moreover, sanding not only gives a more workable mixture but actually shows greater economy in cement yield. Another difficulty which developed with the use of a graded cinder aggregate is the tendency toward segregation of fine and coarse aggregate in transportation and handling. The addition of a silica sand to the mixture was found to be a practical solution of the problem.

Though the introduction of sand to commercial cinders increases the weight of the concrete, it is generally accompanied by increased strength. The author has cited some figures to prove the contrary. The conclusion drawn from the investigations at Columbia University for the New York Bureau of Buildings as reported in Vol. LXXIX, Transactions of the American Society of Civil Engineers was that 800 lbs. per sq. in. is the

minimum compressive strength desirable or necessary to develop the safe load capacities of floor slabs as determined by the empirical formulas developed from these tests. The investigators were not aiming at 800 lbs. per sq. in., but determined that this strength could be practically attained and was sufficient for the purpose of providing an economical, fire-resistive floor filling between structural beams and girders, with an economical cement factor. Higher strengths can be and have been secured by modern control methods; but are economically impractical in application to the short span floor construction. With the modern demand for minimum story heights and maximum number of stories in a given height, there is a tendency toward the use of longer span floor constructions typified by the two-way reinforced slab supported on four edges. The writer believes that the use of a light-weight controlled cinder concrete mixture will be highly desirable for this use, and that further research for this purpose may be required along the lines of controlling the cinder aggregate.

To demonstrate the quality of concrete possible with New York materials and methods, the following observations might be cited. The cinder concrete made on the unsupervised job, as determined by job cylinders of presumably a 1:2:5 mix averaged from 500 to 1000 lbs. per sq. in. compressive strength. Job cylinders made from the same component materials over which the investigators had absolute control of the proportions, produced strengths of 1100 to 1500 lbs. per sq. in. Laboratory cylinders of the same component materials in a 1:2:5 mixture gave strengths as high as 1700 lbs. per sq. in. at 28 days. These data are reported in the paper above referred to. More recent tests on cylinders from jobs in New York City show strengths of 1:2:5 sand-cinder concretes as high as 1300 to 1500 lbs. per sq. in. and the same component materials mixed under laboratory conditions developed strengths as high as 1750 lbs. per sq. in. These values compare very favorably with Dr. Humphrey's results of 1000 to 1200 lbs. per sq. in. for the 1:2:5 and 1500 to 1900 lbs. per sq. in. for the 1:2:4 sand cinder concretes. These too are laboratory results. The amount of mixing water is not reported in the paper for the New York material, but this in general, to the writer's recollection, averaged 12 to 15 per cent by weight of the combined dry mixture or approximately 10 to 12 gals. of

water per sack of cement. Water content was carefully noted in the laboratory specimens and the records probably still exist although not available at the moment of writing. The field specimens were not under the control of the investigators and were purposely selected to represent commercial practice.

By reason of the nature of the poured-in-place construction, any cracks that develop from the volume changes take place along the natural cleavage planes furnished by the enclosing steel frame. The concrete being poured with sufficient water content to give flowability and to coat the embedded reinforcement with cement mortar hydrates sufficiently in the first few months of its life. Thereafter there is little moisture change on the interior of the average occupied building, and consequently little further volumetric change. This is not true of the factory-made, dry cinder unit which is cellular in nature, highly fire-resistant, but purposely manufactured to give a rough surface texture for architectural and ornamental treatments, if in any way subjected to the elements.

The need of a smooth-faced sand in the plastic poured-in-place cinder concrete is quite evident to anyone who has had experience with this aggregate. If more cinder fines are added to the mixture to produce workability, the cement factor becomes uneconomical. In the cinder mix without sand, the water fills the voids of the coarse aggregate and carries some of the cement with it into these cores. The cinder fines do not combine with the cement to form a plastic mortar. The general appearance of the mixture is a mass of coarse unattached particles which are harsh in appearance as well as in working qualities. When the mix is allowed to stand, the water drains out of the cell-like structure of the aggregate and is lost. The addition of the smooth-surfaced particles of sand forms with the cement a plastic matrix which coats and binds the coarse aggregate together. Unlike the cinder fines, the sand tends to hold the water in suspension where it can combine freely with the cement particles.

The writer agrees with Mr. Christensen that there is an extended field for the use of properly controlled sand-cinder concrete, such as for long-span floor constructions. For such usage, further investigation is required to determine the correct water-cement ratio and grading of fine and coarse particles. Cinder

aggregate is generally cellular rather than porous in character and requires a cementitious paste to close these voids and bind the particles together. An excess of cement would accomplish this purpose in a cinder mixture, but not as economically as additional sand in a sand-cinder mixture. The former is a lighter-weight product but lacks the properties of a good concrete.

In connection with the development of a controlled aggregate for light-weight concrete, made by submitting ordinary house ash to a smelting process whereby most of the combustible constituents of the ash are consumed and the non-combustibles are fused into a hard, vitreous clinker of iron-aluminum silicates, and then crushed, screened and graded to a predetermined sieve analysis, an extended investigation was made of the sizing of particles and proportions of fine to coarse aggregates required to produce a practical and workable concrete mixture. This research was done at Columbia University by John S. Peck, Testing Engineer, and the writer has requested Mr. Peck to submit a digest of his findings as a contribution to this subject. The aggregate resembles cinders in many respects, contains about 50 per cent voids, and presented similar problems in the making of concrete, in that an economical, workable concrete could not be produced without sanding the mixture.

BY JOHN SANFORD PECK*

The writer recently spent considerable time on the problem of developing a workable and commercially practical mix using a manufactured material that was projected for use as a light weight aggregate. It was in effect a synthetic cinder.

Very illuminating results developed from this work, and indicated the fallacy of a generally accepted theory. In the writer's opinion, the fineness modulus is of little use in designing concrete mixtures. It is outworn and discredited by the latest practice.

The writer found that minor variations in the grading had no effect on the strength of the concrete. A pinch more or less of one size or another represented wasted effort. The only thing that did affect the result was the relation between the volumes of coarse and fine aggregate in the mix, calling all material

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coarser than ¼ in. "coarse aggregate" and all passing ¼ in., "fine aggregate."

The condition necessary for maximum strength plus maximum workability was, that there should be present enough mortar i. e., fine aggregate and cement, to fill the voids in the coarse aggregate and a little excess to promote workability. In this statement the writer is sustained by no less an authority than Professor Talbot of the University of Illinois in his work on the mortar void theory.

The writer started with a grading that was made up in the laboratory to approximate closely Fuller's Curve of Maximum Density. Call this Grading No. 1. When this mix was tried it was obviously lacking in fines and therefore grading 1A was made up by adding fine aggregate until the ratio of fine to coarse was 1 to 2 by volume. Grading 1B was also made with a fine-coarse ratio of 1 to 1.5. A third grading was made in which the fine-coarse ratio was 1 to 1. Using a real mix that gave a constant cement factor of 5½ bags of cement per cubic yard of concrete, and with all other factors equal, these gradings gave the following results:

Grading	Fine-Coarse	Compressive Strength at 28 Days Lbs. per sq. in.
1		1523
1A	1 to 2	1852
1B	1 to 1.5	1957
1C	1 to 1	1883

These results show that the mix most efficient in strength was one with the fine-coarse ratio of 1 to 1.5. In the writer's opinion, the slump cone does not show workability and to date no acceptable quantitative method has been developed. The workability therefore was judged, not by the slump cone but by the general characteristics of the mix, its "fatness," and the ease with which it could be rodded into the cylinder mould. Grading 1 had no workability at all. It was harsh and rebellious. Grading 1A was not much better, but grading 1B gave a near approach to plasticity and grading 1C gave a true plastic mix.

Mr. Christensen is closer to the real answer to the problem when he speaks of splitting cinders as received on a ¼ inch screen

and recombining on the basis of required strength and workability. The average run of commercial cinders as used in New York is too harsh and lacking in fines to produce either strength or workability and the use of sand to supply that lack is more economical than screening and recombining the cinders to secure the proper proportions. It is the logical conclusion, and experience has amply proved that the 1:2:5 sand-cinder mix fulfills the requirements.

Tens of millions of square feet of sand-cinder concrete construction have been installed in New York City and in no case has fire collapsed a single arch nor has failure occurred where the slab has been in place more than 30 days. To crush or screen the cinders which form such an important part of this construction would be to load up an efficient construction with an expense that would not be justified.

BY E. H. PRAEGER*

All of the many different building materials now available may be used to advantage in the proper place. The author of this report, although actively connected with the production of cinder concrete materials, calls attention to the fact that, while cinder concrete has many virtues, there are conditions under which it may not be suitable.

Cinder concrete has been used as a building material for some thirty odd years. It was developed as a fire-proof floor system and approved in New York City after a series of tests. During the first 10 or 15 years, many tests were made and there was considerable discussion both by those who favored and those who opposed cinder concrete as a floor construction. In the last 10 or 15 years, however, the subject seems to have been forgotten.

The pre-cast cinder concrete unit is of more recent origin, it having been developed as a block for partitions and load-bearing walls for light construction. In some localities these blocks have been used for exterior walls with only a coat of cement paint to act as a water-proofing agent and some very pleasing architectural results have been obtained. Where storm conditions are more severe, this method is not suitable and it becomes necessary to use stucco, brick or stone as a facing material. Recently pre-

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cast cinder concrete lintels have been developed in connection with the use of cinder concrete block construction. A still further development is the use of cinder concrete for pre-cast floor joists. These joists are installed in a manner similar to wood joist construction. The investigations to date seem to warrant a future for this type of construction for light floor loads in places where cinders are available.

The author has covered the subject of cinder-concrete, especially in regard to pre-cast units, in an extremely comprehensive manner. There has been considerable prejudice against cinder concrete at different times, but most of this is probably due to ignorance, and the publication of accurate scientific data and results of tests should help to clarify the existing hazy atmosphere. Recently, the writer was called in by a newly elected mayor at a formal meeting of the school board of a suburban town to advise as to tearing down and rebuilding a new one-story school, then well under construction, because the contractor had used cinder blocks in backing up his brick facing. There had been so many rumors concerning this material that the parents were extremely skeptical about permitting their children to attend school if this alarming condition were not rectified.

It is not surprising, however, that erroneous impressions may exist among laymen, when it is realized that the engineer, even now, has comparatively few data in regard to cinder concrete as used in floor construction. Furthermore, this condition is not helped by those who specialize in other somewhat similar materials and who emphasize the faults in cinder concrete, many of which may or may not exist. Some of the criticisms of cinder concrete are admittedly justified, others are not. This material was developed as a substitute for brick, terra-cotta and stone concrete floors and the questions of fire resisting qualities, corrosive effect on metal (structural steel, reinforcing steel and pipes), permanency, strength, weight, economy, design, manufacture and installation have been discussed at length.

In regard to fire-resisting qualities, laboratory and actual fire tests have demonstrated that a well mixed cinder concrete is at least the equal of any fire-proofing material which may be used in a similar manner.

In regard to corrosion of steel, investigations have proved that the greatest part of the criticism from this source is unjustified. Evidences of corrosion have been noted, but in most cases the cause has been traced to faulty materials or workmanship. In order to obtain the most satisfactory results with cinder concrete, the design, materials and workmanship must be of a high order. It must be admitted that the above requirements do not always exist and our best efforts should be exerted towards improving this condition. The investigations of the author should dispel the overworked and unwarranted fear of the effects of sulphur that may be contained in the cinders. The following paragraph from an article in the *Builder* (England) under date of September 12, 1930, illustrates a very recent English viewpoint.

> Clinker concrete should never be used to cover steel nor be reinforced, on account of its porosity and probable presence of sulphur in the clinkers.

In cinder fill pipes and conduits should be covered with cement mortar before the fill is placed, but in this case the conduits need not be of galvanized metal except in special instances.

As to permanence, we can only state that many square feet have been in place for over a quarter of a century and give no evidence of deterioration. There should be many excellent opportunities for testing actual installations to destruction, as several fire-proof buildings with cinder concrete floors have been demolished and certainly many more will come down in the near future, in order to provide room for more up-to-date buildings. Extensive tests of old slabs in these buildings would give a truer indication of the characteristics of this construction than isolated laboratory tests.

The compressive strength of a uniform run of cinders can be determined, but this may not be relied upon as an accurate comparison of what may be expected in the floor slab as installed in the building, as results of field tests have varied by more than 100 per cent as compared to laboratory tests. The fact that cinder concrete is not as strong and as dense as stone concrete may be an advantage in light manufacturing buildings, the various sections of which may be subject to local vibrations. Such vibrations will be absorbed within a small area and not transmitted throughout the entire structure as would be the case with stone concrete.

As cinder concrete weighs only about 70 per cent as much as stone concrete naturally this fact has a considerable bearing on the tonnage of structural steel as well as on the cost of foundations of a tall building.

As to economy of the structure compared to other systems, this is dependent upon the location of the job and the conditions of the market. When structural steel is low and where cinders are available, it is difficult for any other fire proof system to compete with cinder concrete floors. In the middle west reinforced concrete framed buildings, of the apartment house type, are considerably cheaper than steel-framed buildings with concrete floors, but in New York City steel framed buildings with cinder concrete floors are more economical than any other type of fire proof construction.

There are probably more unknown factors in regard to the design of so simple and yet so important a member as cinder concrete slabs than exist in the design of some of the most complicated engineering structural members. In some localities cinder concrete is designed in accordance with the usual theory of flexure, using about one-half the stress allowed for stone concrete and several other assumed values of constants. In New York City no mention is made of the stress in the cinder concrete but empirical formulae are used to determine the area of reinforcing for different loads, spans and conditions of restraint. These formulae are based upon the results of laboratory tests, which tests are often quite unlike actual job conditions. Whether the concrete acts as a slab, as a flat arch, as a filler between the reinforcing which is in suspension, as a combination of any or all of the above, or whether or not it acts at all, are questions that have not been satisfactorily answered after many years of extensive use of this material.

The fact remains that in different cities entirely different requirements obtain as to the design of cinder concrete slabs. These different requirements give results which cannot be compared, the empirical formulae permitting loadings which in some cases would stress the materials beyond their ultimate strengths as determined by the usual concrete formulae. The empirical formulae were deducted from tests, and the fact that other than

slab action exists is self evident. However, the question of design should receive further study and tests should be continued until we arrive at results which will check with some theory or combination of theories. At this time, to cite only one example, New York City would permit a superimposed load of 400 lbs. per sq. ft. on a 4 in. cinder concrete slab on an 8 ft. span provided 0.36 sq. in. of reinforcing mesh were used per foot of width. For this span and equivalent total load, Los Angeles would require a 6 in. stone concrete slab with 0.46 sq. in. of reinforcing rods. According to the usual concrete formula, the compressive stress in a 4 in. stone concrete slab with this span and load would be 1200 lbs. per square inch. It probably is fortunate that floors are seldom loaded to their full design loadings and it is my opinion that the present empirical formulae are too optimistic and should be made more conservative.

Attention may here be invited to the fact that cinder concrete slabs, which also encase the supporting steel beams in the usual manner, materially increase the strength of these supporting beams and girders. A very complete series of laboratory tests has recently been conducted under the auspices of the Western Society of Engineers, in which cinder concrete and gravel concrete slabs, supported by steel beams (some of which were encased in concrete and others were not) were loaded with several different loadings and readings were taken and recorded. The stresses and deflections of the supporting steel beams and girders were measured by a strain gage and a deflectometer. These quantities were then computed by the usual formulae and the results tabulated as percentages of measured to computed stresses and deflections. These comparisons clearly show the assistance rendered to the structural steel by the concrete fireproofing, especially at design loads. The concrete acts as a stem of a T beam, thus increasing the compression area and raising the neutral axis. Whether or not the same results may be expected with average job conditions is a debatable question. However, as a result of these tests the committee unanimously recommended 24,000 pounds per square inch as the allowable unit stress in structural steel I beams up to 24 in. deep when properly encased in either stone or cinder concrete. Incidentally, the committee recom-

mends the adoption of the empirical formulae for cinder concrete now in use in New York City.

The manufacture and installation of cinder concrete is probably even more important than the question of design. We are living in an age of specialization and while this often proves an advantage, it sometimes has the opposite effect. Cinder concrete is a separate trade and this work is rarely performed by the general contractor. Although the materials are defined in the specifications and the proportions, time of mixing, method of placing, etc., clearly and carefully covered, these requirements are seldom adhered to rigidly. Recently, a reliable cinder concrete contractor, on signing a contract with a general contractor from a near-by city, stipulated that his quotation was based upon his being permitted to install his work without interference by the general contractor. This sub-contractor had no intention of purposely "skinning" the job but he knew that the general contractor was familiar with stone concrete and unfamiliar with cinder concrete installation and rather expected him to be somewhat shocked at the comparison. There seems to be an unwritten law that as far as cinder concrete is concerned, almost anything will do. The specifications for cinders, as proposed by the author, are a step in the right direction, but specifications alone do not insure results. When a load of cinders is dumped in the hopper to be used a few minutes later, it is too late to check up the specifications. The answer of the material man is that they are the best he can get right now, and it is either a case of take what you can get or nothing. There is plenty of room for improvement on the job in regard to careful proportioning of the materials, time of mixing, quantity of water, method of placing and other job conditions. The material is generally mixed in the basement in a continuous mixer and neglected from the time it arrives as raw materials until the forms are stripped. If the designated size of mesh has been stretched over the steel beams, it does not seem to make much difference what location in the thickness of the slab the mesh is placed. Failures have been few but there have been some and it is believed that a more rigid control of job conditions will materially improve the finished product at a very small additional expense.

The possibilities of painting and decorating cinder concrete

directly, thereby saving the cost of lathing and plastering has been given some study and there have been several jobs where the results have been quite satisfactory when sufficient precautionary methods have been taken.

The field tests suggested by the author should be included in the specifications of all important jobs and test cylinders should be taken frequently if for no other reason than the psychological effect on the workmen. Exact proportions of mix, preferably not less than 1:2:4, should be insisted upon. Sieve analyses can readily be made as hand sieves are inexpensive and accurate enough for job control. The quality and uniformity of the cinders can be guaranteed if the engineers insist.

A step in the right direction would be taken if some of the factory methods of manufacturing cinder concrete units were transposed to the job.

BY EINAR CHRISTENSEN

Mr. Strehan opens his discussion with the statement that "the cinder concrete in the factory-made cinder unit of today is not well-made cinder concrete at all." This is decidedly contrary to the writer's experience, and does not appear to be in any way proven by the arguments advanced by Mr. Strehan.

It should be borne in mind that while the mixture used in the making of cinder units is not plastic, it is molded under high pressure. The process is therefore entirely different from that of placing concrete on the job, and the question of consistency cannot be considered in the same light.

As a matter of fact, factory-made 1:7 cinder concrete contains almost as much water per sack of cement as the 1:2:5 sand-cinder concrete discussed by Mr. Strehan. This water does not "drain off rapidly," as Mr. Strehan claims—it is held for a long time by the cellular concrete and is available for hydration of the cement to the same degree as in a sand-cinder concrete.

It is unjust to say that the matter of mixing water is generally neglected in cinder unit plants. The mixer man quickly learns to judge his mix with a fair degree of accuracy, and the figures of 4 to 5 lbs. of water per cubic foot of aggregate, suggested by Mr. Strehan, do not in any way represent mixtures actually used. The figures given by the writer, of approximately 1.5 gallons (12 lbs.) per cubic foot, are typical.

Mr. Strehan assumes that this "dry mixed" cinder concrete causes trouble in the wall. He says that "the high expansional movement of cinder concrete normally associated with its early life is very likely to be prolonged to the masonry in the wall because of the slow hydration of an all-cinder concrete mixture." The fact remains, however, that volume change of cinder concrete masonry, if occurring at all, is a contractional movement similar to that of other concretes, accompanying further hydration of the cement and the drying of the masonry. As shown by the tests quoted in the report, such shrinkage movement is avoided when the concrete units are properly aged and dry.

The writer will be interested in knowing the facts that justify the statement of "lack of durability or permanence in the structure as well as the corrosion of embedded steel occasionally demonstrated by the rusting of nails driven into the masonry." It is contrary to the ten-years experience of the writer in the cinder unit industry. The product has enough history back of it to show its permanence—and the almost universal nailing of trim and grounds to cinder concrete masonry affords ample opportunity to observe the conditions of the nails. That nails driven into the outside of walls may rust, is natural when they are exposed to rain and not sufficiently protected by the surrounding concrete.

To Mr. Strehan, sand is a necessary constituent. That it is frequently desirable in order to produce workability in job-placed concrete is true—that it does not of necessity improve the concrete is shown in the paper. And matters are quite different with cinder concrete building units, molded under heavy pressure.

Mr. Strehan does not think much of the "cinder fines." Nevertheless, his own tests (quoted in the report) show a decrease in strength of sand-cinder concrete when the fines were screened out. Examination of the interior of cinder concrete (molded under pressure) shows a homogeneous concrete—cellular, but nothing like the "mass of coarse unattached particles" pictured by Mr. Strehan.

The supplement by Mr. Peck contains some interesting information regarding the effect of grading. Apparently, the fine-coarse ratios reported have reference to a straight cinder aggregate, indicating what may be accomplished without the addition

of sand. That the latter becomes important where the cinders are lacking in fines, appears obvious. But the self-contained cinder aggregate, reported to split 50–50 on ¼ in., is stated to produce a "true plastic mix."

Mr. Strehan's long experience with sand-cinder concrete in New York adds valuable data on the nature of the New York material. That this "sand-cinder concrete" does not behave exactly like the "cinder concrete" used in machine-made units, is one reason why the writer suggested the two names to differentiate the different materials.

To sum up: It appears to the writer that Mr. Strehan fails to appreciate the fact that factory-made cinder concrete is different from job-made sand-cinder concrete, not merely in having a straight cinder aggregate (graded from coarse to fine) and in having a different consistency, but also in that it is molded under pressure and cured under conditions where the aging can be controlled. Actual performance and accelerated laboratory tests have shown that such factory-made cinder concrete is permanent and offers full protection for any steel properly embedded therein.

The writer has little to add to the interesting discussion by Mr. Praeger. While the matter of design of reinforced cinder concrete was considered to be outside the scope of the report, it is nevertheless an important one as pointed out in this discussion, and it is to be hoped that further work will be done to develop more accurate and uniform specifications.

Readers are referred to the JOURNAL *for December 1931 (Vol. 28), for further disussion. Such discussion should reach the Secretary by Nov. 1.*

A Discussion of a Paper by Raymond E. Davis and Harmer E. Davis:

"Flow of Concrete under the Action of Sustained Loads"*

BY G. A. MANEY† AND M. B. GAMET‡

The well established fact that plastic flow is increased 200 to 300 per cent or more by the drying out of a specimen, which, is identical in all details of mix and strength, leads us to look to shrinkage for an explanation. A paper is being prepared describing the results of a series of experiments at Northwestern University which gives an explanation not only of this phenomenon, but of the decrease in the modulus of elasticity of dry specimens which are identical in strength and mix with specimens tested wet.

A series of pairs of 8 x 32-in. cylinders, one hollow with a ¾-in. shell and the other solid were investigated for shrinkage. 20 in. longitudinal gauge lines were read on the surface of both specimens, and a special 32-in. instrument was designed to read between end points, as shown in Figs. (4) and (5) and was used to get the variation of shrinkage at the several points indicated in the interior of the specimen.

Our best information at present would indicate that the surface shrinkage of the solid specimen will eventually approach closely that of the hollow one, but a tremendous lag is seen in Fig. 3 at all intermediate ages. As this paper is in the nature of a progress report, only 20-day values are available.

Fig. 6 shows the comparative deformations of solid and hollow specimens at age 20 days, and Fig. 7 indicates approximately the

*A. C. I. Journal, March, 1931; A. C. I. *Proceedings*, Vol. 27, p. 837. Submitted as a part of the work of Committee 109, Summary of Plastic Flow, Raymond E. Davis, author-chairman.
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stress distribution which must exist under *no load*. The surface tension f_t is measured by the difference between the unrestrained surface shrinkage e_c, as obtained from the shell, and e'_c which is a restrained surface deformation, greatly reduced below e_c, because of the very slow shrinkage of the interior of the solid specimen. Figs. 8 and 9 show the difference between probable and commonly assumed stress distribution.

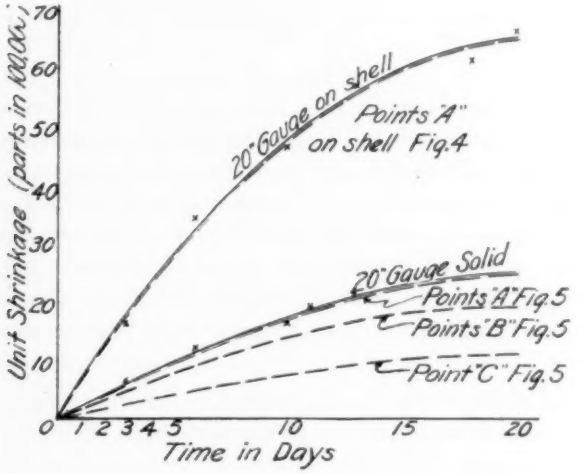


FIG. 3—CURVES SHOWING RELATION BETWEEN TIME AND SHRINKAGE IN SOLID AND HOLLOW 8 IN. X 32 IN. CYLINDERS FOR 1:1:1 MIX (BY WEIGHT) WITH APPROXIMATE 8 IN. SLUMP

If we assume, as is closely true for wet specimens which eliminate the shrinkage problem, that flow is proportional to unit stress, this distribution of stress explains all of the high flow values obtained in the dry specimens discussed in this report. Under low loads the actual stress may be 3 to 6 times greater than the average stress, and only (in the case of the specimens discussed here) at a deformation difference of .00040 which represents 1600 lb. per sq. in. at age 20 days (using $E_c = 4{,}000{,}000$) would this ratio come down even to a 2 to 1 ratio. It is doubtful in a solid specimen of appreciable size whether the interior shrinkage ever reaches the surface value.

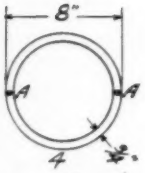


FIG. 4—PLAN OF END OF HOLLOW SPECIMEN

FIG. 5—PLAN OF END OF SOLID SPECIMEN SHOWING LOCATION OF PLUGS FOR READINGS WITH SPECIAL MICROMETER INSTRUMENTS

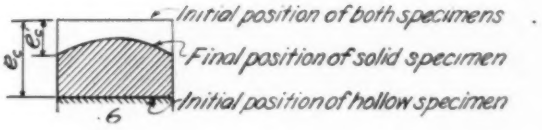


FIG. 6—COMPARATIVE UNIT DEFORMATIONS OF SHRINKAGE ON HOLLOW AND SOLID SPECIMENS

FIG. 7—APPROXIMATE STRESS DISTRIBUTION UNDER NO LOAD

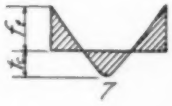


FIG. 8—STRESS DISTRIBUTION UNDER LOAD AT TIME WHEN OUTSIDE TENSION IS JUST ELIMINATED

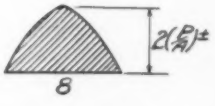
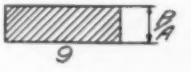


FIG. 9—COMMONLY ASSUMED UNIFORM STRESS DISTRIBUTION



We also wish to submit Figs. 1a to 1d and Fig. 2 (See page 1299), which are practically self explanatory, and which bring out forcibly the fact that a companion specimen with the same steel as a loaded specimen has no bearing on the problem of how the total time increment is divided between shrinkage and plastic flow. In general, when the proper control specimen (which is always plain concrete for a column with vertical steel) is used, shrinkage will account for all of the stress due to time, if no load is applied directly to the steel, but gets to it only through bond as is universally the case in practice. In the specimens of the paper discussed, since load is transmitted directly to the ends of the steel bars, any plastic flow deformations in the concrete cannot take place without carrying the steel along. In practice this is not the case, and so far the specimens tested in the Northwestern University laboratory indicate that flow can take place in concrete around the bars without in any way affecting their stress.

BY J. R. SHANK*

The writers of this paper are to be commended for the easily readable presentation of this work. The writer of this discussion, who had no part in the work of this paper, has some data which he has obtained under different conditions of materials and procedure which he would like to present. Four curve sheets and a sketch are presented bearing on the effect of mineral character of aggregates, on the effect of the amount of load, and on the creep or flow of reinforcing bars in compression splices. These are the results of bachelors' theses carried out at the Ohio State University under the close supervision of the writer.

Fig. 1 shows the results of tests of concretes made up of aggregates of two widely different characters, crushed limestone and silica gravel. The same material was used for both coarse and fine in all specimens. These specimens were made up and tested in a manner similar to that described by the writer in a discussion A. C. I. *Proceedings*, 1928, of a paper by Raymond E. Davis on this same subject. The limestone used was a local product known as Columbus limestone. It is a rather hard fossil-bearing limestone used for concrete and to some extent as a building stone. A notable example of its use as a concrete aggregate is in the Ohio Stadium and as a building stone in the State Capitol at Columbus.

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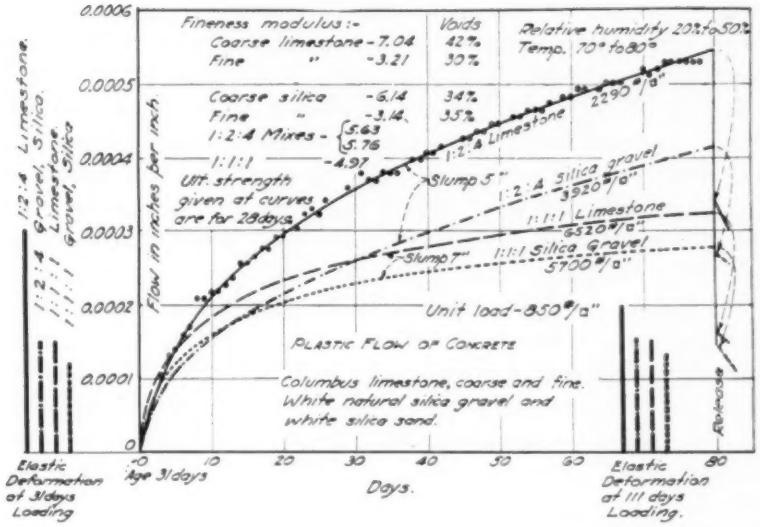

FIG. 1—CURVES SHOWING PLASTIC FLOW OF CONCRETE

It is of a yellowish white color and it breaks in crushing to particles of a generally regular polyhedral shape. There is some tendency to break into somewhat elongated pieces, but none into flat plate-like shapes. The fine limestone aggregate had the fine flour washed out. In this shape it is a commercial product sold for concrete construction. The silica material was obtained from a gravel bank near Akron, Ohio. It has nearly white translucent smooth particles of quartz both coarse and fine.

The investigation was made on two mixes, one a rich mix rather wet and the other a more common mix. The conditions of fineness modulus, consistency and curing conditions were the same in the specimens of each mix. Considering the richer mix, it will be noticed that the amount of flow at 80 days is very nearly inversely proportional to the strengths obtained. This is contrary to the general expectations. The stronger concretes usually flow less. The instantaneous deformations and recoveries appear to be very nearly the same though one occurred at 31 days and the other at 111 days. The leaner mixes show limestone with the greater flow and the lower strength, and the difference is more marked than for the rich mixes.

These specimens were kept during the loading time in ordinary room temperatures and humidities after having been cured in damp sand at about 75 deg. F. room temperature for 31 days. The time of the year was winter and spring. The room was steam heated and the temperature ranged between 70 and 80 deg. F. The relative humidity varied from 20 to 50 per cent which is usual for the interiors of heated buildings for this time of the year where no effort at humidifying the air is made. The changes due to temperature and humidity variations are eliminated from these curves by correcting each reading by a deformation observed on a similar specimen from the same batch cured and stored at all times with the specimen in the test, and treated in all cases the same excepting that it was not under external loading. All four loaded specimens with their respective idlers were kept in the same room. These curves are therefore comparable with each other and can be compared with other curves for specimens under about the same conditions of temperature and humidity. They certainly represent the condition of concretes inside of buildings.

In the cases of both mixes whether stronger or weaker the limestone concrete showed more flow than the silica gravel concrete. This is contrary to the results shown on Fig. 6 of the report. The non-agreement of the results from these two sources indicates that there is considerably more to be learned about the effect of the mineral character of aggregates on flow. As a part of this work an attempt was made to look into the plastic flow properties of aggregate materials themselves. Specimens of three common building stones were secured and put through the same tests as were the concretes. Fig. 2 shows the results. The Columbus limestone came from the same quarry from which the limestone aggregate was taken. The Indiana limestone was furnished by the Indiana Limestone Co., Bedford, Indiana, from quarries of the well known oölitic Bedford or Indiana limestone. The Amherst Sandstone was furnished by the Ohio Cut Stone Co., Cleveland, Ohio. This stone is a fine grained light buff colored silica-bound sandstone. It has a high rating as a building stone. Two specimens were tested, one along the grain and the other across the grain. The specimens were all loaded and unloaded once or twice

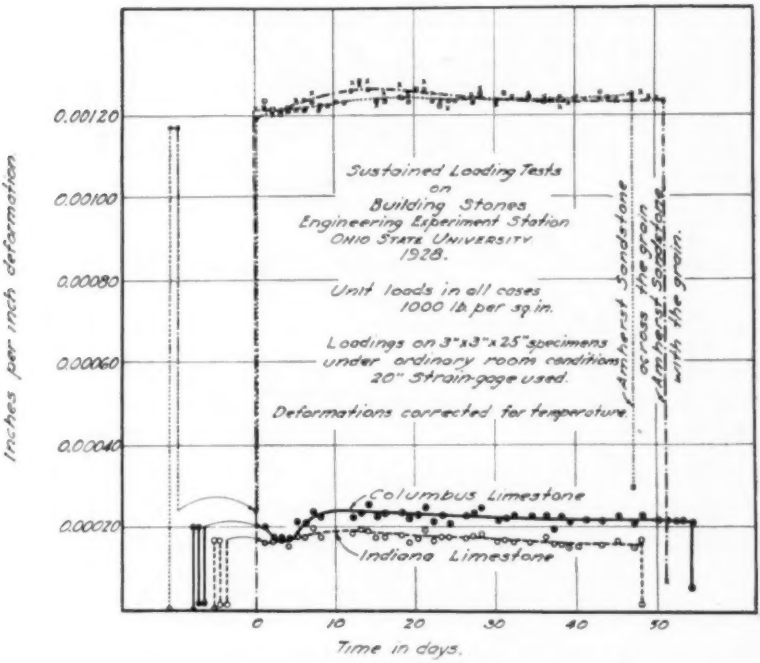

FIG. 2—SUSTAINED LOADING TESTS ON BUILDING STONES

before they were given the sustained loading. Fig. 2 shows this to the left of the sustained loading graphs.

It will be noticed immediately that there is no appreciable plastic flow in these building stones. The Amherst stones seemed to show some in the first few days which, however, was hardly apparent at the end of the 50 days. It is interesting to note the large differences in the elastic properties of these stones and that Fig. 6 of the report shows sandstone as an aggregate to have the greatest flow while Fig. 2 of the discussion shows the Amherst sandstone to have the low modulus of elasticity. It is regretted that Fig. 1 shows no concrete made of Amherst sandstone as an aggregate. These few tests indicate that the plastic flow in concrete is not due to any large flow in the aggregate particles themselves. This leaves the shapes of the particles and the surface conditions to be considered. The amount of surface and the

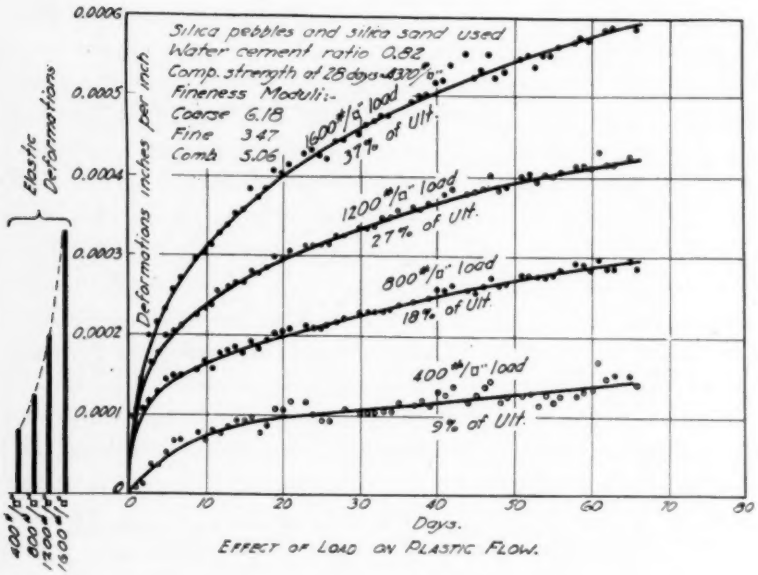

FIG. 3—EFFECT OF LOAD ON PLASTIC FLOW

character of the bonding of the cement to the surface of the aggregate particles are factors to be considered. It appears that other classifications than those given in this report will have to be made before this matter can be finally presented.

Fig. 3 shows additional data on the effect of stress upon air stored specimens loaded at 28 days. This corresponds with Fig. 10 of the report and shows similar results. The discussion shows a stronger concrete in which higher unit stresses were used. The loading period was very much shorter. Here again the conditions were those of a building interior in the winter time. The results from these two sources are in close agreement. Technical Paper No. 12 on building research of the Department of Scientific and Industrial Research of Great Britain by W. H. Glanville, Fig. 10a is also in agreement. Similar results from these three independent sources might warrant the conclusion that in general the flow is proportional to the stress within ordinary working load limits. What occurs for stresses nearer the ultimate load remains yet to be investigated.

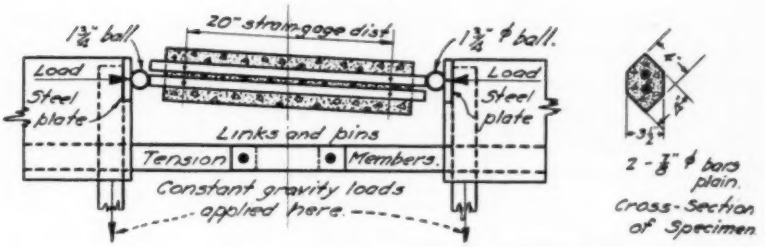

FIG. 4—SKETCH SHOWING SPECIMEN AND METHOD OF LOADING

Figs. 4 and 5 illustrate the results of an attempt to find out whether there is an appreciable bond flow or shear flow in the splices of bars in compression members such as building columns. Fig. 4 shows part of the apparatus used for the flow tests described in this discussion carrying a specimen for this particular investigation. As the load is a gravity load there can be little or no variation in the load. Specimens were made with ⅞-in. plain round bars close, ½ in. clear between, 1 in. clear between and 1½ in. clear between. They were made in pairs and cured in damp sand for 28 days at which time one of each was set up in one of the loading devices. A load of 12,500 lb. was applied to each. The specimen whose bars were 1½-in. clear between failed by diagonal tension. Another pair of specimens of similar concrete was made up, cured and loaded at 28 days with half the load. Strain-gage readings 20-in. long were taken on two sides of the specimens, two on each bar and four from bar to bar. From these data the horizontal movements of the points at one end on one bar was computed with respect to the points at the same end on the other bar. The results for the two ends of the specimen averaged gave the horizontal movement of one bar with respect to the other. These results are shown on Fig. 5 together with the flow of plain concrete of the same batch and of the same cross-section. The unit stress on this plain concrete was 915 lb. per sq. in. For the specimen having bars 1½-in. apart the deformation data were doubled before plotting so as to make the results comparable, assuming that the flow was proportional to the load. To

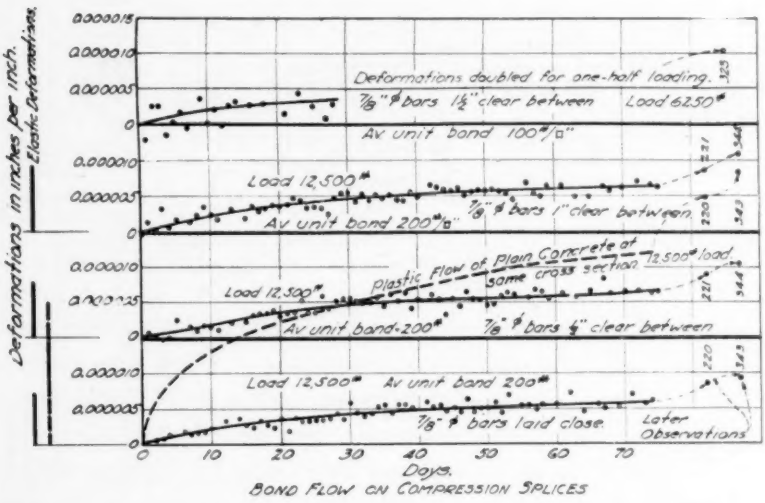
Deformations in inches per inch.
Elastic Deformations
Deformations doubled for one-half loading.
7/8" ϕ bars 1½" clear between
Load 6250#
Av unit bond 100#/□"
Load 12,500#
7/8" ϕ bars 1" clear between
Av unit bond 200#/□"
Plastic Flow of Plain Concrete at same cross section 12,500# load
Load 12,500#
Av unit bond 200#
7/8" ϕ bars ½" clear between
Load 12,500#
Av unit bond 200#
7/8" ϕ bars laid close.
Later Observations
Days.
BOND FLOW ON COMPRESSION SPLICES

FIG. 5—BOND FLOW ON COMPRESSION SPLICES. MIX 1:2.24:2.52 SAND AND GRAVEL W/C = 0.80, SLUMP 3 IN., COMPRESSIVE STRENGTH 4200 LB. PER SQ. IN.

the data of the original thesis were added deformations at later dates which are shown as separate points to the right of Fig. 5.

It is clear that there is a movement of the bars with respect to each other and that this movement must be in the region close to the bars since the distance between the bars has very little effect. We might say that we have "bond flow," but little or no "shear flow" even though the diagonal tension arising from the shear was near the ultimate as was evidenced by the failure of the specimen having bars 1½-in. apart. At the latest date shown the movement for all specimens did not vary from 0.00001 in. per in. by more than 8 per cent. The doubled value for the specimen having bars far apart was within this limit at 297 days. At 74 days loadings the plain concrete flow was 4.3 times the average bond flow, at 220 days, 4.1 times, and at 343 days 3.8 times. This situation must make considerable difference in the distribution of stresses in tall building columns where bar splices occur at every story height. The average unit stress in the steel is, therefore, not as much as the total shortening of the column would indicate. There would also be variations in the unit stresses along the

lengths of individual bars, the greatest being at the middle of the length and usually at the mid-story heights. The carry into the column of bending from floor beam deflections would be greater into the column below the floor than above, since splices are usually made just above the floor. The point of inflections would then tend to be below the mid-story height or where full elastic action on the column would indicate.

BY LARS JORGENSEN*

The paper "Flow of Concrete under Sustained Stress" contains information of a very important nature.

It is still customary when calculating stresses in concrete structures to use the E corresponding to the instantaneous deformation, where—as is shown in this paper, the flow for sustained load greatly influences the working E.

These tests, the writer understands, were started with the object of finding the elastic property of the concrete, which went into the Stevenson Creek dam.

On dam construction an additional factor enters into the problem, namely the watersoaking effect. The results of these tests show quite conclusively that the E for wet concrete is much higher than the E for dry concrete. This is especially of considerable importance in the calculation of dam structures, where part of the dam body is wet and part of it dry, which is always the case when the structure is loaded.

For dam design another property peculiar to concrete is of great importance and that is the watersoaking effect or rather its distribution throughout the section. If the authors would extend their investigation to also include this item, they would have the subject covered rather completely.

The distribution of the watersoaking effect is perhaps quite a difficult subject to investigate, but its importance will justify any earnest attempt to surmount a great deal of difficulty.

For ordinary building design the result of the authors tests points towards the necessity of making two sets of stress calculations, one set using the ordinary or instantaneous E and one set using what the authors call sustained modulus of resistance for concrete under load (for say at least 2 years).

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For dam design the instantaneous E would hardly ever be considered, since the load on such structures comes on gradually and goes off gradually. Take a straight gravity dam for instance,the reservoir being first empty gradually fills up; the stress along the upstream face being first a maximum and later diminishes to nearly zero, while the stress along the down stream face gradually increases from a moderate amount to the maximum allowable compression with reservoir full.

Had the reservoir been empty long enough to produce flow action in the concrete along the upstream face, this face would probably have deflected in an upstream direction. With reservoir full the E for sustained modulus of resistance would have to be used, when calculating the deflection in a downstream direction especially after the reservoir has been full for some time.

The calculated deflection using the sustained modulus of resistance instead of the instantaneous E would be nearly double. To this deflection would have to be added a certain amount due to the watersoaking effect in the cantilever. The upstream face of the dam is 100 per cent wet and the downstream face is dry or nearly so on a well built dam. The upstream face therefore expands vertically relative to the downstream face, this occurrence is compensated for by additional deflection in a downstream direction of the cantilever and without setting up any additional stresses.

The stress distribution along any horizontal joint of a straight gravity dam is not necessarily changed on account of using the sustained modulus of resistance instead of the instantaneous E. This distribution will most likely be in accordance with the theory given by B. F. Jakobsen in a paper before the Am. Soc. Civil Engineers (*Proceedings* Am. Soc. Civil Engineers, September, 1930).

The much larger deflection due to the use of the sustained modulus of resistance instead of the instantaneous modulus of elasticity and the addition to this deflection due to the watersoaking effect is of no special importance for a straight gravity dam, but it is of great importance on a curved dam, because on a curved dam, there is a possibility, that the load may be carried on two systems, arch and gravity (inversely proportional to their deflections).

When calculating the deflection of an arch dam in a down stream direction, the working modulus of elasticity will be considerably higher than the sustained modulus of resistance for dry concrete, since the upstream face is wet when under stress. The portion of the system (cantilever) which might carry load by gravity action is dry where it has its maximum stresses. The wet upstream face expands along the horizontal arch and this is equivalent to an increase in E, a decrease in arch deflection and a decrease or elimination of tensile stress at the abutments.

The wet upstream face also expands vertically, this affects the cantilever as it produces a deflection in a downstream direction without setting up any stresses and therefore without carrying any load. Should the vertical cross section of the dam be such that the deflection of the cantilever due to watersoaking effect in the cantilever is equivalent to the arch deflection, assuming the arch to carry all the load, then the cantilever does not carry any load at all since the water soaking effect in the cantilever made it deflect without setting up any stresses.

If the cantilever deflection due to the watersoaking effect is less than the deflection due to full load on the arch, then of course the cantilever will take some load, since the deflection of the two systems must be the same.

Not so very much is known about the distribution of the watersoaking effect in a body of concrete wet on one face and dry on the opposite face and it is therefore not warranted to assume that the arch receives a definite support from the vertical cantilever.

As already stated, if the authors could be induced to carry on experiments on the distribution of such watersoaking effect in concrete, some valuable information undoubtedly would be forthcoming on this rather dark subject.

CONVENTION DISCUSSION

CLOYD M. CHAPMAN—I was asked the other day whether any tests were made to determine if the sustained load due to the car springs used in the testing apparatus was constant.

RAYMOND E. DAVIS—The springs have been periodically tested to determine whether or not there was any dropping off in load and so far as we have been able to determine within the precision of our measuring apparatus, certainly within 2 or 3 per cent, I

think probably closer than that, it would be within the precision of the measuring apparatus. Therefore we may say that no appreciable dropping off of load has taken place within the limit of the experiment. Any dropping off that has taken place is negligible.

Readers are referred to the JOURNAL *for Dec. 1931 (Vol. 28), for further discussion which may develop. Such discussion should reach the Secretary by Nov. 1, 1931.*

Discussion of Second Progress Report of Committee 105

"Reinforced Concrete Column Investigation"*

BY G. A. MANEY†

The undeniable evidence of this remarkable and much needed investigation is to throw into the discard the time honored assumption of "nf_c" as representing the *total* unit stress in compressive steel. Also the additional stress due to "time" which we may most easily call $e'E_s$, where e' represents the unit deformation due to time yield, becomes a correction which not only doubles but often trebles our unit stress due to instantaneous loading.

Having been in possession of this almost universally unrecognized fact for a number of years and having published several articles as a result of experimental investigation of the compressive steel of beams in our laboratory at Northwestern University, I have been impressed with the seeming indifference of the profession to these facts. For years we have been using a formula for reinforced concrete column design which has introduced this tendency to high compressive steel stresses and have calmly ignored this same phenomenon in the calculation of compressive beam steel. It should be noted however that not even a reasonably small percentage of those using the A. C. I. column formula have understood the conception. Many of those who did realize they were using a code which was based on high design units in compressive steel, were not willing to admit that even stresses approaching the elastic limit in compressive steel under design loads should hide the fact that at ultimate load all the three elements (vertical steel, spiral steel and concrete of core) will be developing as a minimum their full capacities at elastic limit stresses.

*A. C. I. Journal, Feb. and March, 1931; *Proceedings*, Vol. 27, p. 685.

†Professor Structural Engineering, Northwestern University, Evanston, Ill.

The large scale and wide scope of this investigation which goes for the first time into the much neglected field of time loadings must eliminate any doubt as to the astounding divergence between what the average designer of reinforced concrete structures thinks he is getting and what actually occurs. Code changes in *all* compressive steel stresses are inevitable. I see in the recognition of these important findings many possibilities for reduction of size and dead weight where (as is often the case) this is desirable. We begin to realize as we get into these results that from 50 to 90 per cent and (in many cases) all of the column load is carried by vertical steel alone. This leads us to think of a new type of column with greater percentages of vertical steel and much *higher elastic limits* in vertical steel.

Much question of the relative contributions of shrinkage and plastic flow to this tremendous time increase will arise. In our investigations of compressive beam steel under continued load at Northwestern University we have been able to conclude (see *Engineering and Contracting*, June 10th, 1930) that shrinkage has a controlling effect on time stresses in compressive steel and that plastic flow, although an important quantity in plain concrete (as has been shown by Davis and others) is negligible in its effect on increased steel stresses.

The control or companion specimen used to determine shrinkage under no load is the all important detail in separating the two effects.

An examination of Figs. 1*a* to 1*d* brings out clearly the fact that a control specimen such as shown in Fig. 1*b*, of plain concrete and with unrestrained shrinkage unit change of e_{sh} is the only kind which will give any information on the question of shrinkage contribution to the true increment of compressive steel stress. A companion specimen exactly the same as the one under load and having the same compressive steel (Fig. 1*a*) does not tell more than merely how much compressive stress shrinkage *alone*, without the help of load, can throw into steel. The resulting unit change e, has no bearing whatever on the stresses resulting from the column under a deformation e_3 which exceeds e_{sh}.

Fig. 1*d* shows the total stress in compressive steel under load and shrinkage only as $(nf_c + e_{sh}E_s)$, where e_{sh} can only be the unit shrinkage of the plain concrete companion specimen.

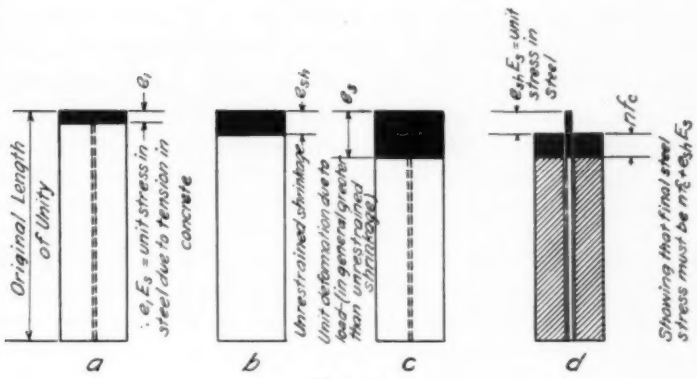
Original Length of Unity
e_1
$e_1 E_s$ = unit stress in steel due to tension in concrete
e_{sh}
Unrestrained shrinkage
e_3
Unit deformation due to load (in general greater than unrestrained shrinkage)
$e_{sh} E_s$ = unit stress in steel
$n f_c$
Showing that final steel stress must be $n f_c + e_{sh} E_s$
a
b
c
d

FIG. 1.

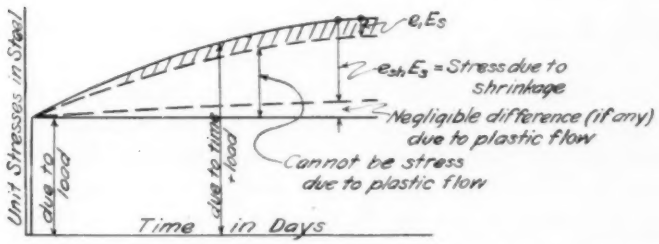
Unit Stresses in Steel
$e_1 E_s$
$e_{sh} E_s$ = Stress due to shrinkage
Negligible difference (if any) due to plastic flow
Cannot be stress due to plastic flow
due to load
due to time + load
Time in Days

FIG. 2—CURVES ILLUSTRATING NEED OF PLAIN CONCRETE SPECIMENS FOR SHRINKAGE CONTROL

It is a notable fact that time increases in measured compressive beam steel check remarkably in an extreme range of cases with the shrinkage of plain unloaded beams of same section with no steel.

It is doubtful if plain concrete shrinkage will fail to account for all except a negligible part of total time increase in the columns of this series. In Fig. 2 is seen the difference in plastic flow effects which would result from a use of the two different kinds of control specimens.

BY WARREN RAEDER* AND HERBERT J. GILKEY†

One of the main purposes of the extensive and admirable column investigation being carried on by Committee 105 is a study of the maximum steel stresses reached in reinforced

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columns due to live load, shrinkage, and flow, and the influence such stresses may have upon the effective strength of the column. Various investigators over the past 20 years, notably McMillan and Lagaard, have reported stresses in the steel approximating yield point values. The question naturally arises: if the reinforcing bars are stressed to the yield point, in what condition is the column to take its load?

The authors of this discussion, in an attempt to study this problem qualitatively, recently cast some compression specimens with the reinforcing bars protruding at the ends so that under test there would be no question about the bars being stressed to the yield point. This stress the bars received before the concrete ends of the specimens came into contact with the testing machine.

A description of the specimens together with the ultimate loads they took is given in Table 1. Specimens 1a to 6a inclusive were of 1:2½:4 concrete with a water-cement ratio of 1.0. The remainder of the specimens were of 1:2:2½ concrete with a water-cement ratio of 1.0 and a coarse aggregate of ⅜ in. to ½ in. pea gravel. The ½ in. square bars used extended approximately ⅛ in. at each end and the ¼ in. round bars .05 in. It will be noted that some of the bars were greased and that in specimen No. 7 the bars were greased and were flush with the ends. All bars had milled ends.

The purpose of the experiment, which was in the nature of reconnaissance only, was to study the behavior of the specimens when the reinforcing bars were definitely stressed to the yield point in order to learn whether the concrete would crack and, if so, how badly; in general, to draw conclusions as to the ability of the reinforced concrete column to take axial load with the steel under a stress at which it would definitely flow parallel to the load, or buckle if not laterally restrained. The specimens were watched particularly at three stages of the testing: (1) at the yield point of the steel; (2) when the specimen as a whole reached its yield point—that is, when it deformed rapidly without taking appreciably greater load; (3) after failure. Continuous stress-strain measurements were taken semi-autographically on all specimens. The specimens were cured under water and tested at 28 days. Results may be summarized as follows:

(1) Specimens without spiral reinforcement cracked badly when the steel reached the yield point. The 3-in.-diameter specimens, with a single ½ in. square bar at the center, failed at this stress while the protruding bars were far from being flush with the concrete; that is, the steel took very little deformation at the yield point before failure by splitting occurred. The similar 6-in. diameter specimen showed cracks at the yield point of the steel (at a total load of 12,000 lb.) but took an additional load of 46,700 lb. (58,700 total) before failure occurred. The bars were about flush at this load. The corresponding specimen, No. 6, with spiral steel, took 162,000 lb. ultimate in the case of the greased bar and 149,000 lb. in the case of the bar not greased (specimen No. 5).

(2) All specimens which had spiral reinforcement were in excellent condition when the stress in the steel reached the yield point. Under further loading, which caused the bars to gradually sink into the concrete until they were flush, some local cracks and spalling developed but in all cases the core was in very good condition.

(3) The specimens with greased bars took, with some exceptions, a slightly higher load than those with bars not greased. Specimen No. 7 with bars greased and also flush showed no cracks at failure at all and was in the best physical condition of all 6 by 12 in. specimens.

The behavior of the specimens with greased bars indicates that perfect bond between concrete and longitudinal steel, which has been a time-honored assumption for purposes of design, is not essential for developing the carrying power of columns under axial load provided some other adequate means is supplied for transferring load to the steel. In the columns of these tests the metal end bearing blocks accomplished the positive transfer of load to the projecting steel bars in the same manner as would be accomplished by properly designed butt joints or flush end plates. It should be understood that the greased bars of the tests were employed only as a device for bringing out a different aspect of fundamental column action. No implication is being made that such construction should be followed in column design.

TABLE 1.

Specimen No.	Size	Reinforcing Bars			Percentage of Spiral	Ultimate Load, lb.	
		No. and Size	Percentage	Greased			
1a	6 by 12 in. cylinder	—	0	—	0	76,300	
2a	"	1—½ in. sq.	0.82	No	0	58,700	
3a	"	"	0.82	Yes	0	67,300	
4a	"	—	0	—	3.2	169,400	
5a	"	1—½ in sq.	0.82	No	3.2	149,000	
6a	"	"	0.82	Yes	3.2	162,400	
1	"	—	0	—	0	111,200	
6	"	—	0	—	3.2	138,000	
5	"	6—½ in. sq.	4.9	No	3.2	203,000	
8	"	"	4.9	Yes	3.2	190,000	
7	"	"	4.9	Yes	3.2	174,400	*
10	3 by 6 in. cylinder	—	0	—	0	28,600	**
11	"	—	0	—	1.4	26,800	
12	"	1—½ in. sq.	3.5	No	0	10,500	
13	"	"	3.5	No	1.4	38,500	
14	"	"	3.5	Yes	0	11,100	
15	"	"	3.5	Yes	1.4	39,200	
16	"	6—¼ in. round	4.15	No	1.4	41,000	
17	"	"	4.15	Yes	1.4	42,000	
18	"	12—¼ in. round	8.30	No	1.4	42,500	
19	"	"	8.30	Yes	1.4	61,300	
20	3 by 24 in. cylinder	—	0	—	0	24,500	***
21	"	—	0	—	1.4	25,000	
22	"	1—½ in. sq.	3.5	No	0	11,000	
23	"	"	—	No	1.4	32,500	
24	"	"	—	Yes	0	10,100	
25	"	"	—	Yes	1.4	38,300	
26	"	6—¼ in. round	4.15	No	1.4	37,400	
27	"	"	4.15	Yes	1.4	40,800	
28	"	12—¼ in. round	8.30	No	1.4	48,600	
29	"	"	8.30	Yes	1.4	50,800	

*Bars flush with ends.
**Average of three specimens.
***Average of two specimens.

Whether it possesses any merit for purposes of construction is beyond the scope of this discussion.

As to the behavior of columns whose longitudinal bars become stressed to the yield point due to shrinkage and flow as well as normal design loads, it is to be concluded from these tests that columns with adequate spiral steel should be structurally safe.

The importance of proper spiral reinforcement can scarcely be over-emphasized. All reinforced column research to date seems to point to this conclusion. In this instance, too, it is evident that the spiral steel furnished the lateral support tending to keep the concrete from splitting and to restrict the splitting when it did start. By confining the concrete surrounding the longitudinal steel it enables the latter to continue to take its maximum stress even though the yield point is reached and it

allows the concrete to approach and even exceed its ultimate strength as indicated by similar specimens of plain concrete.

In conclusion it may be stated that the specimens described above were punished more severely than specimens in which the bars are flush with the surface of the concrete, due to the pressing of the steel into the concrete and the consequent greater force exerted upon the column tending to split it. It is encouraging, therefore, that the results point to the same conclusion as that indicated by previous observations and apparently forecast by the preliminary report of Committee 105, namely, that one need feel no undue concern regarding the structural safety of the reinforced concrete column as a result of the longitudinal steel being rtressed to the yield point provided the column is adequately reinforced with spiral steel. What constitutes adequate spiral reinforcement continues to be one of the major questions before Committee 105.

Readers are referred to the JOURNAL *for Dec. 1931 (Vol. 28), for further discussion which may develop. Such discussion should reach the secretary by Nov. 1, 1931.*

Discussion of Report of Committee 308

"Basis of Design for Hurricane Exposure"*

Discussion of the report of this committee, published in this Journal March 1931, Vol. 27, p. 903, was scheduled for this month. It has been deferred to September 1931, Vol. 28. —Editor

Discussion of Paper by Benjamin Wilk:

"A Comparison of Continuous with Batch Mixers in Plant Operation*"

CONVENTION DISCUSSION

H. B. Emerson: Did you have any way of measuring accurately the water used in the continuous mixer to a given amount of cement and aggregate as in the batch mixer?

Mr. Wilk: No, but we can tell from the face of the block whether or not it has the proper amount of water in it. Variations will show up noticeably—the water web mark is about as good an indication as we could have. If there is too much water the block will slump; if not enough the water web mark will not be there and the possible variation is not a great deal; John Lowell just advises me that the water variation, as so observed, is less than can be conveniently measured.

A. G. Conrow—Did you make any comparison of the number of turns in the use of the continuous mixer and in the batch mixer—the turns of the material.

Mr. Wilk—That question brings up one's ideas of a batch mixer and of a continuous mixer. The batch mixer is called upon to turn together all the cement and all the aggregate which are brought together at one loading. But in the continuous mixer I am talking about, very small portions of the aggregates and of the cement are thrown together at one time so that if for example, four cubic feet of material is divided by thirty-four of the blades, a very small proportion of material strikes a blade at a time, and it is that combination of small amounts of cement and small amounts of aggregate which, to my mind, causes the thorough-

*A. C. I. Journal, Feb. 1931; *Proceedings*, Vol. 27, p. 655. Presented by Mr. Wilk and discussed at 27th Annual Convention, Milwaukee, Feb. 24-26, 1931.

ness of the mixing and which it looks to me is very difficult to get in a batch mixer. If you are going to put in eight cubic feet of aggregate and on top of that throw one cubic foot of cement, it is going to take quite a while to mix it as thoroughly as in a continuous mixer where small portions of the material are thrown together at one time in the mixer trough.

Discussion of Paper by H. F. Faulkner and R. R. Hubbard:

"Design and Control of Concrete for Diablo Dam*

DISCUSSION BY F. R. MCMILLAN

It is very gratifying to have in the *Proceedings* of the American Concrete Institute this description of the concrete and of the unique methods of placing used in the Diablo dam. In both of these features this project provides significant departures from the practice which has become almost standard for large dam construction. The speaker had the good fortune to visit this structure in company with the authors and Mr. Carver, and can testify to the success which attended these methods.

The use of large sized aggregate for structures of this size has

*A. C. I. Journal, February 1931; *Proceedings*, Vol. 27, p. 529. In the absence of the author, the paper was presented at the 27th annual convention, Milwaukee, Feb. 24-26, 1931, by F. R. McMillan, who called attention to the outstanding features of the work and presented discussion as here published.

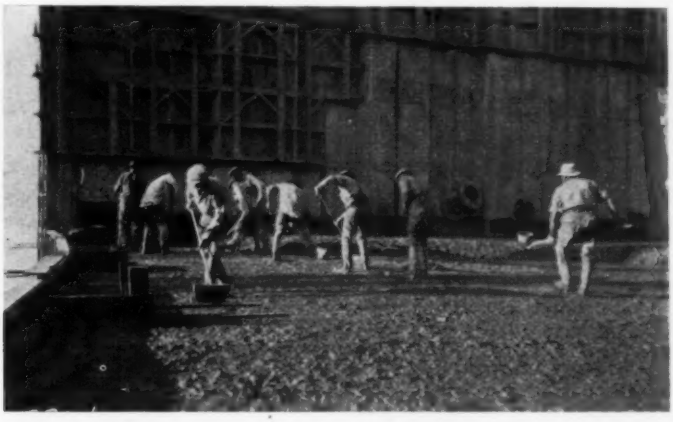

Fig. 1—Brooming surface with mortar just before placing a layer of concrete

FIG. 2—COMPLETED DAM, DIABLO CANYON

become so nearly universal in recent years that the limitation of this aggregate to a maximum size of 4 in. will, no doubt, attract considerable attention. The authors have set forth quite clearly the reasons for this limitation. While advocates of the use of "cobbles" up to 8 or 10 in. can show successful results to offset some of the claims, instances can be cited of results not as satisfactory as at Diablo Dam. The mixtures with 4-in. maximum size showed up particularly well under the method of placing used which, as pointed out before, was also an innovation in constructions of this kind.

Figs. 4 and 5 of the paper show the belt conveyors suspended from the tower and boom. Both towers in Fig. 4 are seen to be rigged in this manner. Fig. 6 shows the "elephant trunk" through which the concrete was deposited. Something of the character of the mixture can be seen from this view. The absence of a great range in sizes, together with the method of placing, practically eliminated all undesirable segregation and required a minimum of handling and puddling.

FIG. 3—COMPLETED DAM. DARKENED PORTION OF FACE IS WET WITH SPRAY FROM STREAMS PASSING THROUGH NEEDLE VALVES

Three views are here added to those presented by the authors with the paper.

Fig. 1 shows the brooming of the surface with mortar just before placing a layer of concrete, as described by the authors. Placing the concrete in thin layers, which can be seen in this picture, insured a thorough puddling and at the same time reduced tendency to the formation of laitance.

The success of the method, of course, can be judged only by the final product. Figs. 2 and 3 show the completed dam with the reservoir practically full. As brought out in the paper there is some leakage on some of the horizontal joints. This leakage however, is restricted to a very small number (less than 1 in 20, it appears from the pictures) and to very small amounts.

This tightness is extremely favorable in comparison with some of the better constructed dams of comparable dimensions in which 8 and 10-in. aggregate was used. The fact that so large a proportion of the joints is perfectly tight is evidence that the mixtures and methods were entirely adequate. Such defects as are noted only emphasize the need for constant attention to all the details of preparation of surfaces and placing the concrete to obtain perfect results.

Discussion of Paper by J. L. Mensch:

"Composite Columns"*

BY FRITZ EMPERGER†

In the infancy of the reinforced concrete era two different view-points opposed each other. One of them leaned towards steel construction and considered concrete as a filler between rigid reinforcements. The other would improve the concrete by flexible reinforcement. Round steel bars finally won general recognition as reinforcement as the question of increased tensile strength became more important. It was soon clear that the round steel bar did not represent the most suitable form of reinforcement for concrete in compression, and a number of limitations have therefore been specified.

These conditions were present during the time I spent in North America. In the beginning of the reinforced concrete era (1890-1896) a city engineer of Philadelphia, simultaneously with me, built a structure with girders of 20-ft. free span, and Ransome in San Francisco built girders of equal span. At that time nobody had the courage to use larger spans with ordinary reinforcing bars. In 1893 to 1894 I designed and built an arch bridge of 70-ft. span in Cincinnati, one of 100-ft. span in Stockbridge, Mass., and also used the Melan system in a number of other structures, which became the few representatives left for the rigid reinforcement which today is seldom used.

After a stay in Paris in 1900, I returned to Vienna and in 1902 I embedded a number of steel columns in concrete. The test results are published in my paper on column construction in *Beton und Eisen*, 1907, page 172, and in *Forscherarbeiten*, Heft 8, Berlin, 1908.

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*A. C. I. Journal, Nov. 1930; *Proceedings*, Vol. 27, p. 263.
†Oberbaurat u. Dr. Techn. E. H., Vienna.

The difference between round steel bars and structural steel shapes as reinforcement for columns should not be considered merely as a difference in form; here occurs a fundamental distinction as regards difference in determination of the permissible load. The permissible load for columns of ordinary reinforced concrete is practically always determined from the equation:

$$P = (A'_c + A_s n) f_c \quad \ldots\ldots (1)$$

Where A'_c = the area of the concrete in the column
A_s = effective cross section of steel.
f_c = permissible compressive stress in concrete.
n = 15.

We see, therefore, that the permissible load is determined by the specified compressive stress in the concrete f_c. This stress appears to be so important that the whole construction depends upon it. It requires no great intelligence to show that this view-point has little justification, since the permissible compressive stress in the concrete can be exceeded without any dangerous results, and safety against failure is the only important item.

The other view-point, however, uses the ultimate strength as the determining factor, and demands such an arrangement of both materials that they work together and that both will be completely utilized until failure. The load at failure of the column is then:

$$P_{failure} = A'_c f'_c + A_s f'_s = P'_c + P'_s \quad \ldots\ldots (2)$$

Where f'_c = ultimate compressive strength of concrete
Where f'_s = ultimate compressive strength of reinforcement.

By means of a given factor of safety we arrive at the permissible load. This load is arrived at still more simply from the equation,

$$\text{Permissible load } P = A'_c f_c + A_s f_s = P_c + P_s \quad \ldots\ldots (3)$$

When both materials have their own factors of safety, the column has an average factor of safety which naturally depends upon which material predominates and which approaches the factor of safety for that material. In the beginning of the reinforced concrete era the possibility of full cooperation was questioned, and I made the tests of steel columns shown in Figs. 1 and 2 with and without concrete in order to show plainly how strengths are added. These figures are found in the fourth edition of my

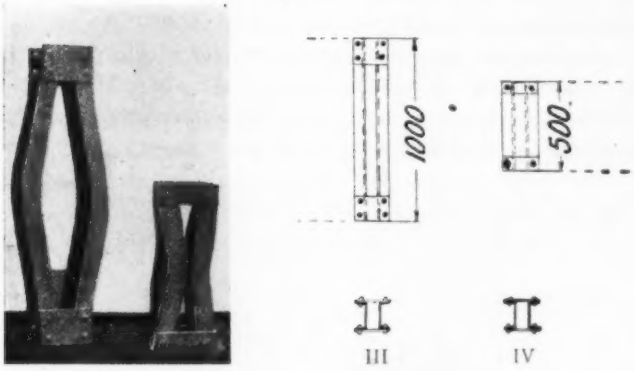

FIG. 1

handbook for reinforced concrete. It has been maintained that the materials will work together up to only 2 per cent reinforcement, but I have made tests with 12 per cent and believe that 20 per cent and more would work just as well with sufficient lateral reinforcement and sufficient strength of the concrete.

In 1910-1911 I made further tests with spirally reinforced steel and cast-iron columns and the results are published in Heft 3 of Reports of the Austrian Committee for Reinforced Concrete (see pages 57 and 116 *Beton und Eisen*, 1912), and found that by means of the lateral reinforcement even the highest compressive strength of steel was fully utilized in adding strength. From the deformation I derived the relation between the elastic carrying capacity and the strength addition, and, as at that time I could find no cheaper iron material than cast iron, I took especial interest in this material. Even though the war had already lasted for one year I was able to present the results of our work at the International Engineering Congress in San Francisco, 1915, and showed that the relation presented in Fig. 3 of the deformation of a column may be considered as the sum of two deformation curves. When the two areas in a reinforced concrete column correspond to A_c and A_s, and the corresponding load curves are P_c for the concrete and P_s for the steel, the addition of the two curves gives the actual deformation curve of the reinforced concrete column in the curve $P_c + P_s$.

This is a long-drawn-out introduction of the question which received almost 12 years interruption by the war and the hard times following the war, but it was necessary in order to go into the investigation which has been reported by Mr. Mensch.

In the first place I may say that it has not surprised me that the American cast iron shows so much lower strength than that used

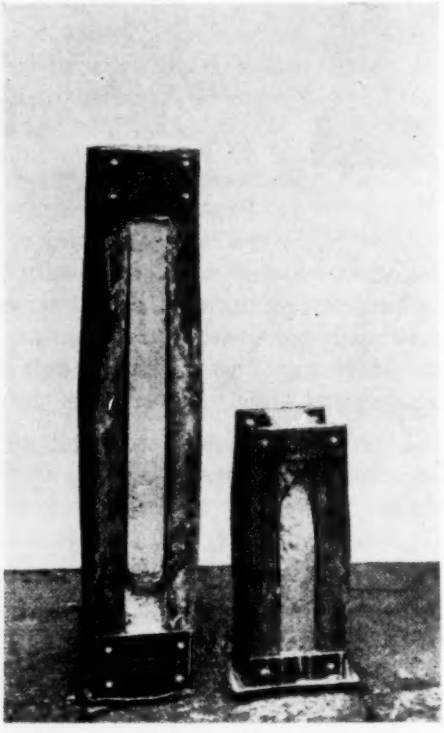

FIG. 2

in my Austrian tests. I have had the same difficulty with the German cast iron. The German and also the American foundries have no interest in producing a cast iron of high compressive strength. This is only a question of composition of the iron, primarily the carbon content. It is important to point out this fact since the question of the cost of producing cast iron with a compressive strength of 150,000 lb. per sq. in. plays no role even

though the ordinary cast iron has a strength of only 75,000 lb. per sq. in. In the specification (see Tetmayer) the minimum strength required for steel for buildings is always 100,000 lb. per sq. in. The Austrian foundries deliver cast iron which without special requirement has 150,000 lb. per sq. in. But in Germany one may get by with a material having a compressive strength approximately that of ordinary steel, that is less than 75,000 lb. per sq. in. (See the deformation curves published by Bach in Heft 3 of the Reports of the Austrian Committee).

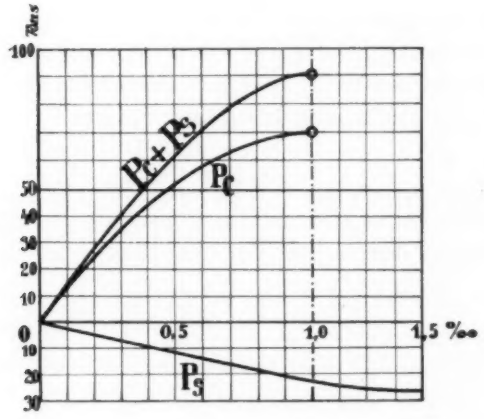

FIG. 3

Nevertheless it is important to note that the foundries have no interest in producing for the ordinary machine casting a material of high compressive strength, which naturally is much harder to work. When we in Austria have a cast iron of such a high compressive strength, it is due to the charge present in the foundries. When one in Germany wants a cast iron of high compressive strength he will have to find a foundry which happens to have a suitable composition. But if he requires a certain compressive strength from the foundry the operators do not know what price to charge for it. Since the use of cast iron for building purposes has practically stopped, they will have to make a special

charge for the work. For industrial use I believe that the situation for cast iron is the same in North America, and a study of the deformation curve would show that. The deformation curve for this kind of cast iron is quite flat and a high ultimate strain is required for the concrete, that is, a large amount of spiral reinforcement of high strength steel, in order to utilize the relatively low compressive strength.

In order to understand what important economical advantage the use of cast iron had in Austria before the war it must be remembered that I easily managed to utilize 100,000 lb. per sq. in. of a cast iron having a strength of 150,000 lb. per sq. in. by using a proper amount of lateral reinforcement, and could make use of permissible stresses up to 20,000 lb. per sq. in. However, when I used ordinary grade steel in columns I was governed by the specification which permits a maximum stress of 570 lb. per sq. in. in the concrete and 8,500 lb. per sq. in. in the steel, so that the utilization of the cast iron to double this amount, and more, would have reduced the reinforcement to one-half and less.

I want to mention that the conditions after the war have caused a considerable change. In Europe the cost of cast iron has increased relatively more than the cost of steel, and the most important factor is that while prior to the war we had to use a steel which at most had a yield-point stress of 34,000 lb. per sq. in., and a corresponding working stress of 14,000 lb. per sq. in., we have at present steel grades on the market with a yield-point stress of 47,000 to 53,000 lb. per sq. in. and permissible stresses up to 22,000 lb. per sq. in. Interest in the use of cast iron has therefore decreased considerably in Europe, especially on account of the official codes. The officials are not inclined to permit anything new, and certainly not anything they believe questionable. Cast iron can without doubt be poorly made and good cast iron requires careful manufacturing and rigid control.

The new methods of making cast iron produce excellent material, but the knowledge has not yet been acquired by the proper officials. It is illuminating in this respect that I have designed and built a number of important buildings and even

official projects in Austria and Czechoslovakia with columns of spirally reinforced concrete and cast iron. In Germany, however, where I designed arch bridges of this material with spans up to 250 feet, I was not permitted to make a single column of this kind, the only reason being the stubbornness of the building officials.

I cannot, however, explain the error limiting only to cast iron the viewpoint presented in the addition method given in equations 2 and 3. I have always made designs both with cast iron and with steel and left it to the contractor to decide which method to choose. We have even made far-reaching tests with high strength steel for the purpose of obtaining specifications for columns of steel skeletons. This work was published in March, 1931, as Heft 12 of the Reports of the Austrian Committee for Reinforced Concrete. In the following a short summary of these tests is given:

(1) The average deformation of ordinary concrete in a column amounts to 0.1 percent. This value will not be exceeded in a column with ordinary ties, showing that at failure the longitudinal reinforcement can not be utilized to more than 29,000 lb. per sq. in. whatever the yield point stress of the steel.

(2) For spirally reinforced concrete columns the shell outside of the spiral deforms with the column up to a deformation of 0.2 per cent. If only a small amount of spiral reinforcement is used (as is the case when the spiral is not intended to increase the strength but only for the utilization of the yield-point stress of the steel) the total cross section of the column can be used in the computation. It is not necessary to use only the area of the concrete within the spiral as has been common practice up to the present time.

(3) By the use of rigid structural shapes for reinforcement or of independent cast-iron columns, a direct increase in strength is obtained and the use of a small amount of spiral reinforcement will raise the strength as for the round iron reinforcement.

(4) These tests have recently proved the correctness of equations (2) and (3) regarding the "law of addition." With our limited means we managed to make 42 column tests during the summer of 1930. We aimed at a few typical examples and showed

how the strength of the steel column can be increased by 72, 108 and 172 per cent, by a simple embedment in concrete spirally reinforced. For such a skeleton half of the reinforcing steel can be saved by this arrangement which is so necessary with respect to safety against damage by fire. I have to my surprise read a circular from the American Institute of Steel Construction[1] wherein complaints are made against the fire insurance companies in the United States for specifying a thick concrete shell for steel frame buildings. This shell is considered only as dead weight. If this is dead weight they themselves are to blame because they evaluate the concrete so low. If they recognize that the concrete shell contributes to the strength, they can save half the steel weight by the utilization of an arrangement which is required anyway and so actually costs them nothing. I believe that this method will lead to a compromise between the competing methods of steel and reinforced concrete constructions. This method may be carried back to the early days of my stay in the United States nearly 40 years ago and I am glad to have been able to contribute my small share to the development of American building construction.

BY R. SALIGER*

Having made during the last years a great number of tests the Laboratory of the Vienna Technical College is in a position to add materially to the knowledge on composite columns. All tests were made very carefully as regards materials and methods in order to obtain that high degree of uniformity necessary for scientific comparison. The tests were made with columns of Dr. Bauer's system with cast iron skeleton and with hard steel bar skeleton.

(*A*) *Cast iron skeleton*—During 1928 tests were made on 48 columns partly of 47 in. and partly of 109 in. length. The columns were square or round, the hooping following the square or cylindrical form on the outside. The cast iron skeleton consisted of 4 bars having a total area of 5 sq. in., 10 sq. in. and 15 sq. in. respectively. The bars were of rectangular section and were held together by cast iron rings thus forming one rigid skeleton. The

[1]"Fireproofing Structural Steel," by Jack Singleton, published by American Institute of Steel Construction, 1929.

*Prof. Dr. ing., Vienna University Technical College.

cast iron core was from 4.6 to 15.3 per cent of the total area inside the hooping. The spiral consisted of round mild steel wire of 0.2 in., 0.28 in. and 0.4 in. diameter respectively at 1 in. to 4 in. pitch. The spiral was from 0.5 to 4 per cent of the hooped area. The concrete mixture was 1 part cement to 4 parts sand, cube strength being 2,870 lb. per sq. in. and cylinder strength 2,020 lb. per sq. in., age 15 days.

The ultimate strength of the cast iron core was 113,600 lb. per sq. in. Tests of all spiraled columns showed that with very slight variations the ultimate strength is given by the formula:

$N_{ultimate} = F_k \sigma_p + F_g \sigma_g + 2.2 F_s \sigma_s$

F_k = hooped concrete area

F_g = area of case iron core

F_s = equivalent area of spiral reinforcement.

σ_p = cylinder strength of concrete 2,020 lb. per. sq. in.

σ_g = utilizable resistance against compression of cast iron 68,160 lb. per sq. in.

σ_s = yield point of spiral wire.

According to results obtained the total resistance to compression of the cast iron core was utilized up to 63 per cent. The long columns carried at failure 15 per cent less than the short ones.

(*B*) *Hard steel bar skeleton*—During 1929 and up to 1931 four series of tests of columns from 47 in. to 120 in. long were made at the Vienna and Berlin laboratories. (Technische Versuchsanstalt Wien und Material Prüfungsanstalt, Berlin).

The spiral hooping of all columns was 12 in. in diameter, the outside diameter of the columns being 13.4 in to 13.8 in. The spiral consisted of round wire from 0.2 in. to 0.28 in. diameter at 1 in. to 2 in. pitch. Flat iron hooping was also used. The spiral was from 0.5 to 2.0 per cent of the hooped area. The hard steel bars had a tensile strength from 113,600 lb. to 142,000 lb. per sq. in and a yield point in compression of 106,500 lb. per sq. in. The diameter of the longitudinal bars was from 1.2 in. to 1.7 in.; their number varying from 4 to 6 in each column. The metal area of the core represented from 3.8 to 11.2 per cent of spiral area.

There were 10 to 20 columns tested in each series. By selecting sand and gravel of good quality and by careful mixing great uniformity and quality of the concrete was obtained throughout. Otherwise the results would scarcely have formed a sufficiently reliable base for comparison.

We may arrive at the ultimate strength of the columns, with very slight variations, as follows:

$N_{ultimate} = F_k \sigma_p + F_e \sigma_e + 2.9 F_s \sigma_s$

σ_e = yield point of the longitudinal steel bars embedded in hooped concrete = 113,600 lb. per sq. in.

The efficiency of hooping turned out to be 2.9 times the efficiency of longitudinal reinforcement with material of the same quality and weight. The utilizable resistance against compression of hard steel core was 113,600 lb. per sq. in., thus being greater by 6 per cent than the actual yield point in compression of the naked steel bars.

By comparing the results of four series of tests the following conclusions were arrived at:

1. The strength of the metal core will be fully utilized if the spiral represents 0.5 per cent of the hooped area.
2. Increasing the hooping results in an increase of the resistance of hooped concrete only.
3. Columns 120 in. long show a carrying capacity 15 per cent smaller than that of columns 47 in. long.
4. The utilizable resistance to compression of columns with steel bars welded of two pieces is 10 per cent less than that of columns with bars in one length, not welded.
5. The carrying capacity of the columns is determined by the combined resistances to compression of the concrete core, of the metal core and the tensile strength of the spiral.
6. With small loads the hooped concrete and the metal core remain one solid mass. With big loads the outer layers crack and fall off sooner or later before the stress at failure is reached, according to strength of the metal core.

(*C*) *Structural steel skeletons*—Recently 10 columns with structural steel skeletons, spirals and concrete were tested. All columns were 120 in. long, had octagonal form and 13.8-in. out-

side diameter. The structural steel core consisted of two channel sections, 4 in., 6 in. and 7 in. in depth, held together by gusset plates. The spirals consisted of bars 0.2 in. and 0.28 in. thick at 2 in. pitch. The yield point of structural steel was from 35,220 to 37,200 lb. per sq. in. The tensile stress of the spiral wire was from 35,500 to 39,800 lb. per sq. in.

The concrete mixture of 1:5 resulted in a cube strength of 2700 lb. per sq. in. and a cylinder strength of 2100 lb. per sq. in. at 30 days.

All tests gave extremely uniform results regarding load at cracking of outer layers and load at failure. Loads at cracking were from 4.7 to 13.1 per cent under maximum loads.

At failure the stress in the concrete was estimated equal to the cylinder strength. Stresses in the structural steel were 10 per cent greater than the above mentioned yield point. No sideways buckling was observed.

Most columns are so short that the spirally reinforced concrete would fail before the column buckled. The strength of such a column would be the summation of the strengths of the spirally reinforced concrete plus the load borne by the cast iron at the ultimate strain of the spirally reinforced concrete, unless the per cent of cast iron is unusually high.

BY JOHN TUCKER, JR.*

The concrete column reinforced with spiral and cast iron that may be justly termed the Emperger column has proven of merit in actual construction. Mr. Mensch is to be congratulated upon his sustained interest in presenting information and obtaining data on this type of column.

The tests that have been made upon columns of this type unfortunately have given insufficient data upon which to obtain constants based on a sound theoretical analysis. In particular, the control specimens that would give the strength of the concrete in the reinforced columns are very meager. The ultimate strain and the modulus of elasticity of the spirally reinforced concrete up to the ultimate strain should be known. The Emperger columns tested in the United States have had flat ends bearing directly upon plates on the platens of the testing machine. The amount of

*Bureau of Standards ,Washington, D. C.

motion of the spherical bearing under such conditions is small, and the tests approximated the condition of fixed ends. The movement that did occur[1], however, confused to a considerable extent the conclusions that might be drawn from the tests.

If, instead of empirical equations that hold for each set of tests only, as have been obtained, completed data were secured upon columns tested with definite end conditions, the critical length (for buckling) could be computed by the Engesser-Considere theory[2]. It is regretted that this splendid column theory which has been experimentally confirmed[3] for cast iron has not been applied to the interesting Emperger type; and it is also to be regretted that the theory is not familiar to more engineers in the United States.

Mr. Mensch gives values of .001 and .01 for the ultimate strain of plain and spiral reinforced concrete; these values are approximately correct but may be sufficiently misleading to warrant correction.

The average ultimate strain of unreinforced concrete[4] is approximately .0014 in. per in., the individual readings varying from .0010 to .0018, approximately. The ultimate strain of the spiral reinforced column is under .008 in. per in., some experimentally obtained values being as low as .003. The test data indicate that the higher the per cent of spiral reinforcement the greater the ultimate strain.

AUTHOR'S CLOSURE

Prof. Dr. R. Saliger contributes the result of about 100 tests on composite columns. It is gratifying to note that not once in his discussion does he make use of the ratio of the moduli of elasticity of metal and concrete, commonly denoted by n. The reason is that the strength of reinforced concrete cannot be explained by the use of n which changes in value at every change of loading.

This discussion contains also a clear cut statement that the action of the spiral hooping is proportional to the yield point of the wire, a truth appreciated by very few engineers. The tests on

[1]See for example Bureau of Standards Technologic Paper No. 122.
[2]See Meyer, Die Knickfestigheit, 1921, p. 69.
[3]See for example Die Knicksicherheit an beiden Enden gelenkig gelagerter Stabe aus Gusseisen. T. Yuki—Sendai Higher Technical School, Japan, June 11, 1930.
[4]Refer to Talbot, Bul. No. 10, University of Ill. Exp. Sta. Withey, Bul. No. 666, University of Wisconsin Eng. Series, Bureau of Standards Technologic Paper 122 and many other papers.

hooped columns with square spirals which proved to be nearly as efficient as round spirals are new to American practice.

Although the cast iron used in Dr. Saliger's tests was of lower strength than that used by Dr. Emperger the ultimate stress per sq. in. was higher than in the American tests because of the very low value of the l/r of the cast iron skeletons. The series B of Dr. Saliger's tests with skeletons of high carbon transmission shaftings is very instructive in view of the fact that many city codes and specifications do not permit higher stresses on high carbon bars than on medium steel bars. After giving the hooped concrete in this series all possible credit for the strength it contributed, the remaining part of the ultimate load divided by the area of the steel skeleton amounted to 113,600 lb. per sq. in., which is 6 per cent larger than the yield point. Here we attribute to steel bars a stress of only 30,000 lb. per sq. in. at the ultimate load and consider high carbon bars of no advantage in columns. These tests ought to be effective in dispelling this error.

Series C with structural steel cores gave nearly identical results with the columns 11 to 14, made by the writer, and shown in Table 4.

Mr. Molitor's discussion[1] is answered by Dr. Saliger's and Dr. Emperger's discussions.

John Tucker, Jr., who did the actual testing of the Emperger columns at the Bureau of Standards' Pittsburgh Laboratory in 1916, voices regret in his discussion that no attenpt has been made to obtain data for a sound theoretical analysis of composite columns. The writer wishes to emphasize that, notwithstanding the fact that thousands of extensometer tests have been made on simple concrete beams, (which tests show to be nearly twice as strong as the accepted theory teaches), we have no reliable data to explain their behavior, and all the extensometer tests made on spiral columns have not taught American engineers to use only high elastic limit steel for spiral and vertical reinforce-

[1] A. C. I. Journal, March 1931; *Proceedings*, Vol. 27, p. 947.

ment, and that all our positive and valuable knowledge of the strength of materials consists of more or less empirical data, derived from practice or tests. The modulus of elasticity of concrete varies greatly after ½ of the ultimate strength is reached, as it does for cast iron, while the common theory which assumes a constant modulus of elasticity leads engineers astray and prevents them from adopting new combinations of materials.

Discussion of paper by M. O. Withey:

"Some Long Time Tests of Concrete"*

AUTHOR'S CORRECTION

P. 549, in the ninth line from the bottom of the page, change *25 deg.* to *— 25 deg.*

P. 559, in the first column of Table 5, third line below headings, change *expansion* to *contraction.*

BY W. K. HATT

Professor Withey's paper on "Long Time Tests of Concrete" contains Fig. 8, showing the relation between volume-change and loss or gain of water in curing.

The diagram in my Fig. 1 shows these relations from the several series of tests performed in the Laboratory for Testing Materials of Purdue University during the last two or three years. The notations on the figure give information of the nature of the aggregate, the concrete mix, etc.

It is apparent that the law connecting change of weight, resulting from gain or loss of water, and change of length, obtained by strain gage measurements, is not a straight line relation. This relation varies with the richness of the mix.

The duration of constant immersion or constant air drying as represented in Fig. 1 varied from 24 hr. to 130 da. at which latter time the specimens had closely approached a period of equilibrium.

The zero hour of beginning the measurements was 24 hr. subsequent to a period of 24-hr. curing of specimens in a damp atmosphere.

*Presented at the 27th Annual Convention, A. C. I., Milwaukee, Wis., Feb. 24-26, 1931. A. C. I. Journal, February 1931; *Proceedings*, Vol. 27, p. 547.

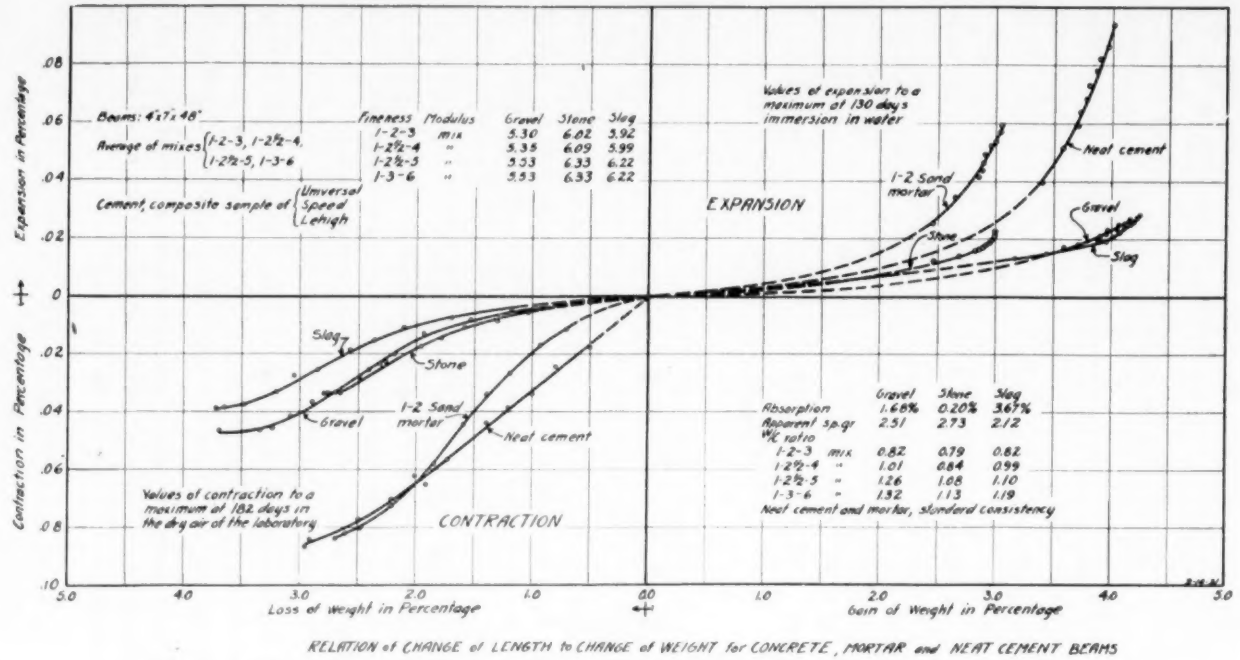
Beams: 4"x7"x48"
Average of mixes {1-2-3, 1-2½-4, 1-2½-5, 1-3-6
Cement, composite sample of {Universal, Speed, Lehigh
Fineness Modulus Gravel Stone Slag
1-2-3 mix 5.30 6.02 5.92
1-2½-4 " 5.35 6.09 5.99
1-2½-5 " 5.53 6.33 6.22
1-3-6 " 5.53 6.33 6.22
Values of expansion to a maximum of 130 days immersion in water
EXPANSION
1-2 Sand mortar
Neat cement
Stone
Gravel
Slag
Values of contraction to a maximum at 182 days in the dry air of the laboratory
CONTRACTION
Absorption 1.68% 0.20% 3.67%
Apparent sp.gr 2.51 2.73 2.12
W/C ratio
1-2-3 mix 0.82 0.79 0.82
1-2½-4 " 1.01 0.84 0.99
1-2½-5 " 1.26 1.08 1.10
1-3-6 " 1.32 1.13 1.19
Neat cement and mortar, standard consistency
Contraction in Percentage + Expansion in Percentage
Loss of Weight in Percentage
Gain of Weight in Percentage
RELATION of CHANGE of LENGTH to CHANGE of WEIGHT for CONCRETE, MORTAR and NEAT CEMENT BEAMS

FIG. 1—RELATION OF CHANGE OF LENGTH TO CHANGE OF WEIGHT FOR CONCRETE, MORTAR AND NEAT CEMENT BEAMS

CONVENTION DISCUSSION

M. O. WITHEY—I would like to suggest that the coordinates to this curve, Fig. 1, are not the same as shown in my Fig. 8. In my Fig. 8, I show loss of water in gallons per sack of cement. Professor Hatt's figure shows loss or gain as a percentage of the weight of the sample of concrete. If his figure is changed so that the coordinates agree with those shown in my Fig. 8, I think there will be more marked agreement in the two sets of data.

BY DUFF A. ABRAMS

A study of concrete strengths by the same organization and on the same cement over a period of 20 years is unique in engineering literature. I wish to congratulate Prof. Withey on this excellent report. I hope he will be here to present the final report when the 100-year tests are completed.

At the Lone Star Research Laboratory in New York City, we have carried out during the past few months, an extensive series of compression tests of concrete using:

2 cements
6 mixtures
3 consistencies for each of above conditions
6 ages at test (others to follow)

Our tests have a direct bearing on certain phases of Prof. Withey's work. I wish to speak particularly of the age-strength relation for concrete made of cements of different characteristics using a wide range of mixes and consistencies and to call attention to other significant phases of these tests.

The speaker pointed out in 1918[1] that the strength of concrete was a function of the logarithm of the age at test. This conclusion was based on tests from many American and European laboratories which were available in the literature at that time. The recent tests referred to above have shown that this logarithmic relation is not general for all cements, mixes and consistencies. The logarithmic relation was true for the cements and mixtures used a dozen years ago, but does not apply to modern cements

[1] "Effect of Age on Strength of Concrete" by Duff A. Abrams, *Proc.* A. S. T. M. Part II, 1911. p. 317.

and the richer or drier mixtures (that is concrete of the lower water-ratios).

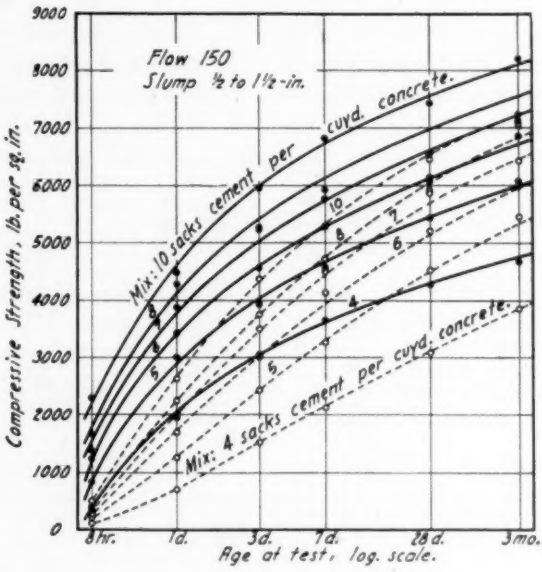

FIG. 1—AGE-STRENGTH CURVES FOR CONCRETE OF FLOW 150 PER CENT

Compression tests of 6 x 12-in. cylinders cured in moist room.
Sand and gravel aggregates.
Each point is the average of 2 tests.
Solid curves, High-Early-Strength Portland Cement.
Dotted curves, Ordinary Portland Cement.

Figs. 1, 2 and 3 show age-strength curves for concrete ranging in cement content from 4 to 10 sacks per cu. yd. of concrete. Compression tests were made on 6 x 12-in. cylinders cured in moist room. Each figure is for concrete of a definite flow as measured by 15 ½-in. drops of the 30-in. flow table. The solid lines represent the high-early-strength cement; the dotted lines, ordinary portland.

Many will recall that formerly little attention was given to concrete strength at ages earlier than 28 days; later we became more venturesome and made tests at 7 days; lately the test

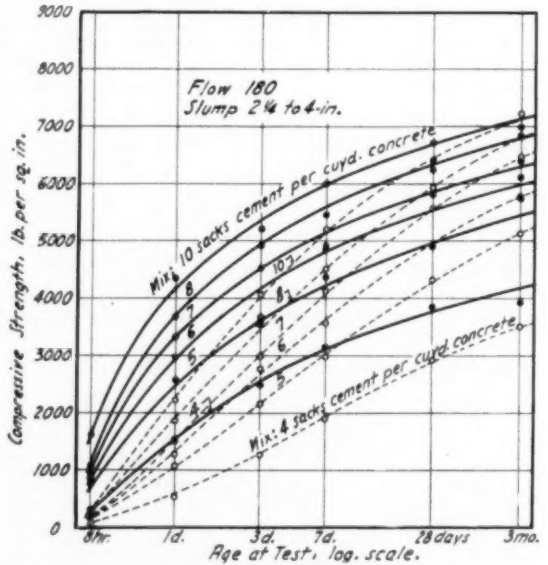

FIG. 2—AGE-STRENGTH CURVES FOR CONCRETE OF FLOW 180 PER CENT

Compression test of 6 x 12-in. cylinders cured in moist room.
Sand and gravel aggregates.
Each point is the average of 2 tests.
Solid curves, High-Early-Strength Portland Cement.
Dotted curves, Ordinary Portland Cement.

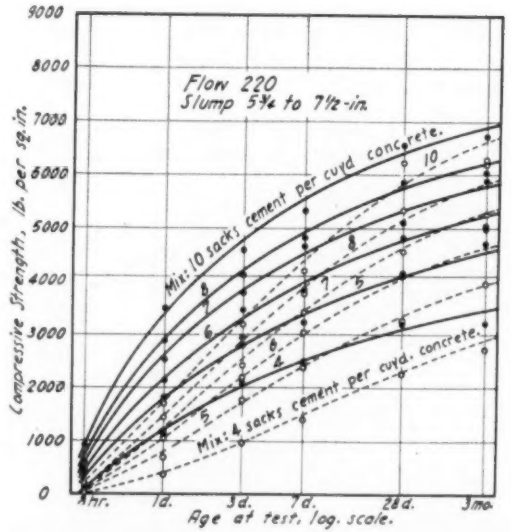

FIG. 3—AGE-STRENGTH CURVES FOR CONCRETE OF FLOW 220 PER CENT

Compression tests of 6 x 12-in. cylinders cured in moist room.
Sand and gravel aggregates.
Each point is the average of 2 tests.
Solid curves, High-Early-Strength Portland Cement.
Dotted curves, Ordinary Portland Cement.

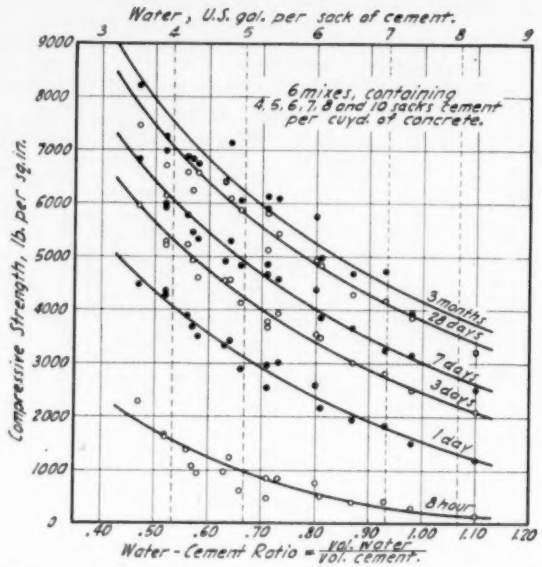

FIG. 4—WATER-RATIO—STRENGTH CURVES FOR HIGH-EARLY-STRENGTH CEMENT

Compression tests of 6 x 12-in. cylinders cured in moist room.
Each value is average of 2 tests.
Same tests as in Figs. 1, 2 and 3.

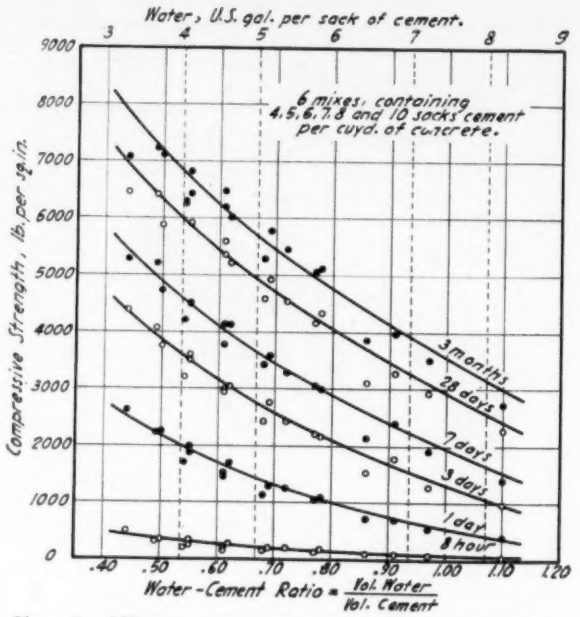

FIG. 5—WATER-RATIO—STRENGTH CURVES FOR ORDINARY PORTLAND CEMENT

Compression tests of 6 x 12-in. cylinders cured in moist room.
Each value is average of 2 tests.
Same tests as in Figs. 1, 2 and 3.

periods have been reduced to 3, 2 and 1 day and now tests are regularly made as early as 8 hours.

It is only the leaner mixes of ordinary portland cement which give essentially straight lines when plotted to a logarithmic scale of ages. It is interesting to note that relation holds for test periods as early as 8 hours. As soon as we get into the richer mixtures and drier consistencies (low flow) the lines curve upward sharply and depart materially from straight lines. The modern cements and richer mixtures have a rate-of-increase-in-strength at early periods which is much higher than the older cements and leaner mixtures which were prevalent a dozen years ago. This high rate has the effect of throwing the curves much higher on the scale—too high for the logarithmic relation to hold.

Figs. 4 and 5 are the same tests plotted with reference to the water-ratio of the concrete; separate curves are drawn for each age. These curves are in the form with which you are familiar and show that both cements give water-ratio strength curves of exactly the same form. The only difference is in the age at which a given cement reaches a designated position on the diagram.

If now we plot the curves in Figs. 4 and 5 to a logarithmic scale of strengths we find a very interesting relationship as shown in Fig. 6. All of the water-ratio curves become straight lines regardless of type of cement or age at test and they all intersect the ordinate for zero water at a single point marked A.

The equation of all these curves may be written in the form

$$S = \frac{A}{B^x}$$

where S = the compressive strength
x = water ratio (an exponent)
A and B are constants

This is the same equation which I used in 1918 in the original publication of the water-ratio law[2] for concrete strength. It was then stated that "A and B are constants which depended on the quality of the cement used, age of the concrete, curing conditions, etc." It was my original thought that each cement had a dis-

[2] "Design of Concrete Mixtures" by Duff A. Abrams, Bulletin 1, Structural Materials Research Laboratory, Lewis Institute, Chicago.

tinctive value for A, however these tests give an entirely different view and suggest that A is an *invariant* which is common to all portland cements and that B is quantity which varies with quality of cement and the age at test. As the quality of the

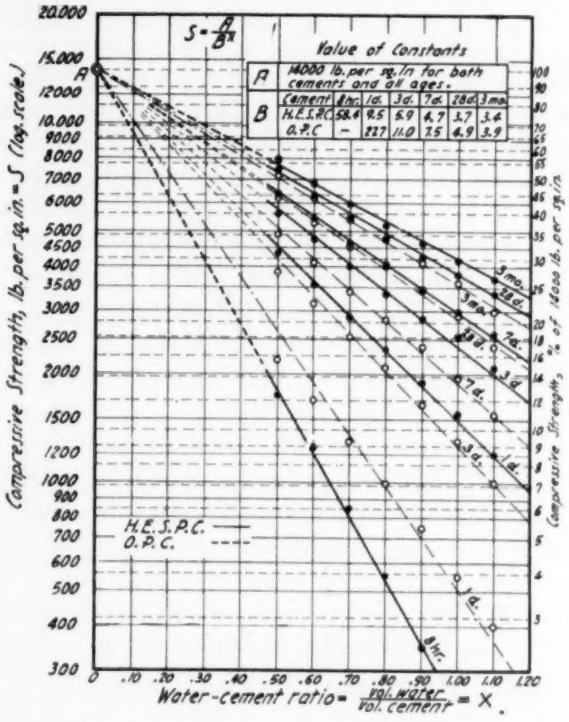
S = A/B^n
Value of Constants
A 14000 lb. per sq.in for both cements and all ages.
B
Cement | 1 hr. | 1 d. | 3 d. | 7 d. | 28 d. | 3 mo.
H.E.I.R.C. | 58.4 | 9.5 | 5.9 | 4.7 | 3.7 | 3.4
O.P.C. | - | 22.7 | 11.0 | 7.5 | 4.9 | 3.9
Compressive Strength, lb. per sq.in. = S (log. scale)
Compressive Strength, % of 14000 lb. per sq.in
H.E.S.P.C.
O.P.C.
Water-cement ratio = vol. water / vol. cement = X

FIG. 6—WATER-RATIO—STRENGTH CURVES FOR CONCRETE
Same curves as in Figs. 4 and 5, strengths plotted to a logarithmic scale.

cement or age at test increases the value of B becomes smaller. B is the slope of the curves on this diagram.

All of the water-ratio strength curves in Fig. 6 are seen to be rotating about the point A. The quality of cement (as measured by B) simply *dictates the age at which a given strength will be reached.* In other words cement quality may be defined in terms of a rate of increase in strength at early ages.

That A is a most interesting invariant is indicated by the fact that it is the same (14,000 lb. per sq. in.) for the modern cements

as for the cements tested 15 years ago. It is no accident that Prof. Withey's tests give this value for A when plotted on our Fig. 6.

The point A is in itself an absurdity, since it is a concrete strength for a zero water-ratio; however it does have a real significance in indication of a "ceiling" or ultimate strength which all concretes, of whatever grade of portland cement, mixture or water-ratio approach, so long as they do not dry out.

My interpretation of the significance of A is that it is impossible to mold concrete under gravitational forces only which will develop strength greater than 14,000 lb. per sq. in. This, of course, applies to 6 x 12-in. cylinders and to the particular routine of testing which is now commonly followed. The consolidation of concrete under pressure appears to give a much higher "ceiling."

The tests in Bulletin 1 referred to above gave $B = 7$ at 28 days for ordinary portland cement. The table in Fig. 6 gives for ordinary portland cement $B = 4.9$ at 28 days and $B = 7.5$ at 7 days. The modern "ordinary cements" give strengths at about 9 days equivalent to the 28-day strength of the cements manufactured 15 years ago; the high-early-strength cement gives the same strength at about 2 days.

Each point on Fig. 6 represents some combination of cement quality, water-ratio and age. These are the 3 factors which go to make up concrete strength.

The scale at the right of Fig. 6 enables us to read off the percentages of the "ceiling" strength reached at any water-ratio or age; for example with a water-ratio of 0.80, ordinary portland cement has 7 per cent of its strength at 1 day; high-early-strength cement has 17 per cent. At 7 days we have 21 per cent and 28 per cent. For higher water ratios the spread between the two cements is greater and at lower water-ratios the spread is less than the values given.

The *time element* is of fundamental importance and appears to be the only real difference in concretes made and tested under standard conditions and cured damp.

The exact causes for this definite "ceiling" in concrete strength of portland cements are not clear. There are not many reports of tests which throw light on these questions, due to limited range in water-ratio, age, etc. Further studies will undoubtedly throw much new light on many features of concrete properties and behavior.

Readers are referred to the JOURNAL *for December 1931 (Vol. 28), for further discussion which may develop. Such discussion should reach the Secretary by Nov. 1, 1931.*

ABSTRAÇTS

ABSTRACTS

of the current literature of cement and concrete

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COMMITTEE ON ABSTRACTS

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MATERIALS

ADMIXTURES

Slaked lime as a means towards denser concrete. R. GRUN. *Summary Reports First I. C. for C. and R. C.*—Relations between impermeability and strength of concrete: Against physical effects; against chemical action. The making of watertight concrete: Effect of lime upon: plasticity, tensile and compressive strength, compactedness, resistance to frost, resistance to chemical action.—LA TECHNIQUE DES TRAVAUX

Effect of several admixtures on portland cement. P. P. BUDNIKOFF AND M. I. NEKRITSCH. *Zement* (Germany), Feb. 26, 1931, V. 20, No. 9, p. 192-3.—In experiments at laboratory of technology of silicates in Charkow (Russia), cement was mixed with 1, 2, 5, 10 and 30 per cent of each of following materials: chalk, dolomite, dolomite burned at 750° F., dolomite burned at 1470° F., marl and marl burned at 1110° F. Admixtures were ground together with clinker in laboratory ball mill. Standard 1:3 mortar specimens were made for compressive and tensile strength tests and stored in water and artificially made sea water. Tensile strength of pure cement is in general slightly higher than that of cements with admixtures. Compressive strength is mostly improved by above materials. Admixtures increase density and adsorbing properties of mixtures. Additions of as much as 10 per cent do not affect value of cement. Most economic admixture is chalk. Large scale tests along same lines are in progress.—A. E. BEITLICH

AGGREGATES

The composition, mixing, methods of application of concrete and reinforced concrete as used in the yards and the control of same. T. R. GRIGSON. *Summary Reports First I. C. for C. and R. C.*—The paper is divided into various headings which may be summarized as follows: Composition of concrete; cement, aggregates, proportioning, admixtures and fillers. Mixing concrete; methods of application.—LA TECHNIQUE DES TRAVAUX

The application of sieve analyses and Abrams' fineness modulus. A. HUMMEL. *Summary Reports First I. C. for C. and R. C.*—Influence of gauge of inert materials on strength of mortar and concrete has been zealously studied in laboratories during past 25 years. Results obtained have been correlated in ideal granimetric curves (Fuller, etc.) or rules for gauging. The value of these curves for scientific research and for laboratory practice is unquestionable, but for use on the works it is questioned. This paper indicates a more general method of estimating qualities of inert materials from grainmetric point of view.—LA TECHNIQUE DES TRAVAUX

Criticism of fineness modulus. A. HUMMEL. *Zement* (Germany), Feb. 5, 1931, V. 20, No. 6, p. 129-34.—Author discusses investigators' comments on his paper "The valuation of sieve analyses and the fineness modulus by Abrams" *Zement* (Germany), April 1930, V. 19, No. 15, p. 355-64; JOURNAL A. C. I., June 1930, V. 1, No. 8, *Abstr.* p. 108. Too refined mathematical calculation can not be applied to this subject without making method valueless for practice. Advantages and disadvantages of method, especially its speed of calculation, are illustrated.—A. E. BEITLICH

Ideal curve, fineness modulus and the new standard specifications. KRISTEN. *Zement* (Germany), April 16, 1931, V. 20, No. 16, p. 366-9.—A comparison is made of ideal curve, curve by Otzen and Abrams' fineness modulus. New text of German standard specifications for reinforced concrete is discussed. Best and most economic way to improve a material is to compare its sieve analysis with ideal curve (without cement). If it is necessary to add coarse materials, percentages of these additions can be found with fineness modulus by method of Hummel. Graphical method for plotting curves is explained, especially conversion of Tyler sieve openings into metric equivalents. —A. E. BEITLICH

About mesh openings and particle sizes. JOHS. ANDERSEN. *Zement* (Germany), March 5, 12, 1931, V. 20, No. 10-11, p. 224-6, 242-5.—Study was undertaken to replace measurement of mesh openings in sieve analysis by determination of average diameter of particles which can just pass sieve when sieving process is completed. This fraction is called size separation (Kornscheide). Investigation covered (1) pure separation, (2) relation between average mesh opening and size separation of certain sieves, (3) demonstration of sieve analyses and (4) size separation of sieves with different materials. Fineness curves are much smoother than those based on mesh openings. Relation of size separation to mesh opening is about 0.81 in case of mostly spherical particles and slightly less for particles with sharp edges.—A. E. BEITLICH

Synthoporit—A new light-weight structural material. H. F. KRAUSE. *Zement* (Germany), April 16, 1931, V. 20, No. 16, p. 372-4.—A very porous material is prepared from a fusion of calcium silicate. Melt leaves furnace at 2730 to 2910° F. and is chilled by patented process. Cold slag is then broken and sieve separated into certain fractions. Material consists of about 20 per cent solids and 80 per cent voids. It floats on water even after 3 months. It is not affected by high temperatures and its strength is not materially decreased when used as concrete aggregate and exposed to high temperatures. Chemical composition is close to wollastonite, 47-49 per cent SiO_2, 2-4 per cent Al_2O_3, 0.2-0.5 per cent FeO and 43-45 per cent CaO. Sulphur is below 0.3 per cent. Specific gravity is 0.6. Voids are mostly closed and do not absorb much water. It is highly heat insulating. Greatest field of application is concrete. It is used for manufacture of slabs, light weight bricks, ceilings, encasings for steel structures and walls. Concrete with synthoporit as aggregate has very favorable strength properties.—A. E. BEITLICH

Gravel plant of unusual design. H. M. FITCH. *Rock Products*, March 14, 1931. V. 34, No. 6, p. 33.—Hillside Washed Sand and Gravel Co.'s plant at Muskego, Wis., has screening and washing machinery mounted on an octagonal tower. Walls, or fins, run out from each angle of tower making eight spaces. Conveyor for recovering materials is installed in one space leaving seven for storage. Boot of conveyor is in base of tower and chutes from all divisions lead to it. A hoist is moved on a circular track around the storage to handle a scraper bucket to pull material in and out of storage spaces.—EDMUND SHAW

Quarry practice at the operations of the John T. Dyer Quarry Co. *Rock Products*, Feb. 28, 1931, V. 34, No. 5, p. 47.—The John T. Dyer Quarry Co., which has three plants near Birdsboro, Penn., is developing blasting technique and solving the problem of making the fines into a commercial product. Coyote holes are used at the Monocacy Plant. They are driven from a tunnel about 100 ft. back of the face, this tunnel being connected to the surface by a vertical shaft. The face is 300 ft. high and two tunnels will break the rock in two benches. At the Clingan Quarry well drill holes are set 20 ft. apart with 35 ft. burden. The rock broken ranges from 6 to 7 tons per lb. of powder. Four ton auto car trucks haul the rock to the crusher. The main crusher of the Monocacy Plant (60 by 84 in.) was once the largest jaw crusher in the world. Drive for this is most unusual. Fines have been sold as fine aggregate and recently part of them have been ground very fine to be used in the recovery of fine coal.—EDMUND SHAW

Proposed method of test for soundness of fine and coarse aggregate by use of sodium sulphate. Appendix 2 to the fifth annual report of the engineering and research division of the National Sand and Gravel Association. *Nat. Sand Gravel Bul.*, Feb., 1931, V. 12, No. 2, p. 41-42.—A procedure to be followed in treating fine and coarse aggregates to determine their resistance to disintegration by a standard solution of sodium sulphate, and equipment to be used. The solution, prepared by dissolving sodium sulphate in water at about 86° F., is allowed to cool to 70° F. and stand at least 12 hr. before use. For fine aggregate samples a balance of not less than 1,000 grams, sensitive to at least 0.5 gram, is required. Fine aggregate

passing ⅜-in. sieve shall be of such size that approximately 500 grams is coarser than No. 50; that portion finer than No. 50 shall be discarded. Fractions retained between No. 50 and 30, 30 and 16, 16 and 8, 8 and 4, and coarser than No. 4 sieves shall be weighed and placed in separate containers. For coarse aggregate samples a balance of not less than 5,000 grams, sensitive to at least 1 gram, is required. Coarse aggregate shall consist of material from which sizes finer than No. 4 sieve have been removed. Pieces showing incipient fracture due to crushing shall be removed. Weight of sample shall depend on maximum size of aggregate. Fractions retained on ⅜, ¾ and 1½ in. (square openings) shall be weighed and placed in separate containers. Number of particles shall be counted in fraction coarser than ¾ in. Immersed samples shall be stored at 70° F. for a period of 18 hr., and dried in an oven (from 212 to 230° F.) to a constant weight (not less than 4 hr.) then allowed to cool to room temperature. Care must be exercised to avoid loss of aggregate particles or detritus coarser than 100 mesh. Alternate immersion and drying shall be repeated until five cycles (unless otherwise specified) are obtained. Fractions coarser than ¾ in. shall be examined qualitatively after each cycle and quantitatively after completion of test. Fractions finer than ¾ in. shall be examined quantitatively only and after completion of test.—P. MCKIM

Aggregates and the physical properties of concretes: their coefficient of elasticity and their resistance to compression, tension, flexure, shear and impact. R. DUTRON. *Rev. materiaux construction trav. publics* (France), July, Aug., Sept., Oct., Nov., Dec., 1930, No. 250, p. 258-62; No. 251, p. 293-8; No. 252, p. 343-9; No. 253, p. 383-9; No. 254, p. 431-5; No. 255, p. 473-7.—The coarse aggregate was Rhine or Meuse pebbles, or crushed porphyry, slag or sandstone; fine aggregate was Rhine sand or finely crushed porphyry. Some experiments were made with fine slags also. The best compressive strengths were obtained with mixtures of sand and gravel, because of the better packing so that less water was required. Three gradings were used with three different amounts of cement at three different consistencies each. Two kinds of cement were used. The concrete made of river sand and gravel is stronger under compression than when made of crushed rock. Deformability of concrete is influenced by the grading of sand and by the ratio of fine to coarse. Tensile results generally reversed those of compression, porphyry giving better values than gravel and fine crushed rock better than sand. Ratio of tensile to compressive decreases parabolically with age and for crushed stones lies in the range 0.093 to 0.075, while with water worn aggregates, 0.070 to 0.052. The flexural strength equals 1.63 times tensile + 12.5 per cent. Shearing resistance was determined by making beams with an offset center and was found to be closely proportional to compressive strength. Resistance to impact was determined. Specimens of crushed aggregate withstood pounding better than water worn materials. Mixtures gave intermediate results.—F. O. ANDEREGG

CEMENT

The cause of the "sanding off" of high alumina cement. A. F. ROSCHER-LUND. *Zement* (Germany), Feb. 19, 1931, V. 20, No. 8, p. 164.—Softening and sanding off of layers of pats of certain high alumina cements is due to too rapid drying out of surface causing incomplete hydration of cement. Carbonation which has been found to take place in these layers is only of secondary nature and not directly responsible for sanding effect. Opinion of H. W. Gonell on this subject is discussed.—A. E. BEITLICH

The cause of setting failures of high alumina cement. H. W. GONELL. *Zement* (Germany), Feb. 19, 1931, V. 20, No. 8, p. 164-8.—Contrary to findings by Roscher-Lund, (cf. *Zement* (Germany), Feb. 19, 1931, V. 20, No. 8, p. 164), carbon dioxide and not too rapid drying is cause of sanding off of high alumina cement test pats. Tests carried out in previous years were repeated. Specimens were stored in moist air, moist carbon dioxide atmos-

phere, moist oxygen and dry oxygen. Same results were obtained. Differences in findings are due to different lime contents of investigated cements. Drying out of surface layer is only of minor importance.—A. E. BEITLICH

Notes on the use of special cements on the Netherlands East Indies state railways. P. A. JELLEMA. *Summary Reports First I. C. for C. and R. C.*—Rapid hardening cements of French, German and British manufacture have been used and in no case were strengths claimed for them obtained. It was established that capacity for rapid hardening diminished with the lapse of time. Control tests indicate that for the present these special cements should, therefore, only be adopted with the greatest care. The reason why the special cements deteriorate in quality is not yet known.—LA TECHNIQUE DES TRAVAUX

Improvements increase output of Dewey cement plant at Davenport, Ia. *Pit and Quarry*, April 8, 1931, V. 22, No. 1, p. 49-55, 61.—Plant which has been using closed-circuit wet finish grinding for about one year, first went into operation in 1927 but numerous improvenents were made prior to 1930, such as development of a new quarry level and a new clay pit, addition of several locomotives, enlargement of the crushing plant, installation of equipment for sizing aggregate for commercial trade, a clay-wash mill, a third kiln and a cooler, a wasteheat boiler, 24 storage silos, and slurry filters.—A. J. HOSKIN

Determination of magnesium in portland cement and similar materials by the use of 8-hydroxyquinoline. J. C. REDMOND AND H. A. BRIGHT. *Bur. of Standards Journ. Research*, Jan. 1931, V. 6, No. 1, p. 113-20.—Procedure given for determination of magnesium in portland cement is accurate and much more rapid than standard phosphate method. Directions for preparation of solutions are given. Determination can be carried out in about 2 hrs.—A. E. BEITLICH

Contribution to the ball mill theory. W. BARTH. *Zement* (Germany), April 23, 1931, V. 20, No. 17, p. 390-1—Reply to article by Naske (cf. *Zement*) (Germany), Feb. 12, 1931, V. 20, No. 7, p. 148-9) in which author states that materials in ball mills are only crushed by impact and not also by attrition. He explains ways of particles in mill and theory by Fischer. Naske gives his final opinion which is contrary to conception of author.—A. E. BEITLICH

About the manufacture of fused cement. WALTER MARSCHNER. *Zement* (Germany), April 16, 1931, V. 20, No. 16, p. 362-3.—Improvement of electric furnace for manufacture of high alumina fused cement facilitates discharging of materials. Temperature of melt must be raised considerably at point of discharge. This can be done economically by adding about 20 per cent of raw mixture to melt at outlet of furnace. Exothermic reaction of chemical constituents in mix causes rise in temperature which is sufficiently high for discharge. German patent (P 58,489) has been applied for.—A. E. BEITLICH

The degree of lime saturation by Kuhl. M. SPINDEL. *Zement* (Germany), April 9, 1931, V. 20, No. 15, p. 338-40.—A contribution to the question of final form of degree of lime saturation derived by Hans Kühl and modified by Hess (cf. *Zement* (Germany), Jan. 8, 1931, V. 20, No. 2, p. 28-32; JOURNAL A. C. I., April, 1931, V. 2, No. 8, *Abstracts*, p. 214). Author demonstrates degree of lime saturation in his four-component parallelogram and suggests further changes of this modulus. Application in practice is discussed. Kühl, in addition to his previous paper (cf. *Zement* (Germany), Feb. 5, 1931, V. 20, No. 6, p. 123-5), criticizes efforts by Hess and Spindel to modify his formula and claims that "degree of lime saturation" is only to be used for his original modulus.—A. E. BEITLICH

The degree of lime saturation by Kuhl. M. SPINDEL. *Zement* (Germany), April 16, 1931, V. 20, No. 16, p. 360-2.—Continuation of polemic between Spindel and Kühl (cf. *Zement* (Germany), April 9, 1931, V. 20, No. 15, p. 338-40). Author claims that calculation of his formula and of Hess' number can be simplified greatly by mathematical manipulation. Kühl gives short

reply and states that practice must decide which method is most suitable for proportioning of raw materials.—A. E. BEITLICH

The formation of minerals from melts of kaolin-lime mixtures. I. WEYER. *Zement* (Germany), March 19, 1931, V. 20, No. 12, p. 264-5.—Mixtures of kaolin and lime were heated above sintering point and formation of minerals investigated to determine whether tricalcium silicate, already formed at this temperature, undergoes any changes. Five different brands of metakaolin and lime in proportions 1:8, 1:9, 1:10 and 1:12 were heated from 5 to 6 hr. at 2640° F. Mostly dicalcium silicate in beta form was observed in mixtures with less than 9 mols CaO. In mixtures with more than 9 mols CaO no dicalcium silicate was observed; all silica is combined as tricalcium silicate. —A. E. BEITLICH

The lime content of high alumina cement. HANS KUHL AND SETSUO IDETA. *Zement* (Germany), March 19, 1931, V. 20, No. 12, p. 261-4.—Efforts were made to determine most favorable lime content for high alumina cements by preparing several synthetic melts and studying their physical properties by small-piece testing method. Ratios of SiO_2:Al_2O_3:Fe_2O_3 were 15:35:10, 10:40:10 and 5:45:10. Lime contents in these cements ranged from high to low limit, calculated by means of formula for degree of lime saturation derived by Kuhl (cf. *Tonindustrie Zeitung* (Germany), March 20, 1930, V. 59, No. 23, p. 389-92). No direct relation was found between physical properties and chemical composition.—A. E. BEITLICH

Analysis of standard cements. H. BURCHARTZ. *Zement* (Germany), March 19-26, 1931, V. 20, No. 12-13, p. 258-60, 290-2.—A method has been worked out under supervision of Burchartz, Gruen, Guttmann, Haegermann and Luftschitz for analysis of portland cement, iron portland cement and blast furnace cement. Directions are given for preparation of samples, solutions and their standardization. Analysis includes determination of loss on ignition, silica, sesquioxides of iron and aluminum (special method is given for samples containing more than 1.5 per cent manganese), lime, magnesia, insoluble residue and sulfate.—A. E. BEITLICH

New ways in American cement manufacture. CARL NASKE. *Zement* (Germany), March 19-26, 1931, V. 20, No. 12-13, p. 266-8, 292-6.—Review of several articles gives special consideration to installations at American plants. Following points are considered as most essential: (1) Improving quality to effect that high early strength cement will be manufactured more than ordinary standard portland cement; (2) Investigation of wet process and increase of fineness of raw mixture and cement; (3) Lowering of production costs by slurry filtration; (4) Increased application of closed circuit grinding and use of vibrator screens and classifiers at raw feed end and air separators for cement; (5) Improved dust collecting systems and greatest attention to safety devices.—A. E. BEITLICH

Researches on the rotary kiln in cement manufacture.—Part 13. GEOFFREY MARTIN. *Rock Products*, Feb. 28, 1931, V. 34, No. 5, p. 72.—In calculation of theoretical flame temperature in a rotary kiln, it is assumed that 1-lb. coal gives gaseous mixture CO_2, 2.624 lb.; N_2, 7.669 lb.; H_2O, 0.448 lb.; excess air, 0.537 lb.; total, 11.278 lb. Air, including 5 per cent excess is put at 10.478 lb. and it is assumed to have a temperature of 60° F. Highest temperature that can be attained by combustion gases is about 4,000° F. To calculate the maximum temperature, the mean specific heats between 4,000 and 60° F. of the components of the combustion gas are taken from the author's tables of specific heats. (The water is supposed to be gasified at 60° F. and then heated to the maximum temperature T.) Then approximate flame temperature of T deg. F. is calculated and found to equal 3763° F. In this calculation assumption is made that specific heats of gases follow a straight line law between 60° and 4000° F. and also that mean specific heat between 60° and 4000° F is same as that between 60° and 3763° F. These

assumptions introduce two slight errors. Formula for calculating flame temperature is modified to: Total heat equals heat liberated by 1-lb. of coal plus heat brought into furnace by 10.478-lb. of air, equals 12,600 B.t.u. plus QT. A table is appended showing the B.t.u.'s required for preheating 10.478-lb. of air from 60° F to various temperatures. By substituting in the formula various values of QT in table, approximate flame temperatures corresponding to different temperatures of preheating are found. More exact determinations are then made. The difference between the B.t.u.'s absorbed in heating furnace gases from 60° F to 1481° F., and 12,600 B.t.u.'s is heat absorbed in heating gas from 1481° deg. F to its final temperature of T deg. Final formula works out to: $T = \frac{7972 + Qt}{11.278 \times S_T} + 1481$ where T equals the flame temperature deg. F, Qt equals the B.t.u.'s brought into furnace by 10.478-lb. of air, and S_T mean specific heat of the combustion gases between 1481° and T deg. F. The various values of Qt taken from Table 1 and the varied values for S_T corresponding to approximate flame temperatures in the second table are substituted in the formula and different temperatures calculated. The final table shows flame temperatures beginning at 3769° F., when air is admitted at 60° F. to 5370° F. when the air is preheated to 2500° F.—EDMUND SHAW

High early strength cements and their increase in strength. P. MAY. *Tonind Ztg.* (Germany), Feb. 9, 1931, V. 55, No. 12, p. 171-3.—Strength measurements up to 5 years show a general increase. Sometimes temporary retrogressions are encountered.—F. O. ANDEREGG

The geology of gypsum. V. CHARRIN. *Rev. materiaux construction trav. publics* (France), March, 1931, No. 258, p. 99-101.—The deposits of gypsum which supply 2 million tons a year around Paris, in Lorraine and Provencales occur either in triasic or miocene formations.—F. O. ANDEREGG

The enumeration of French cement plants. PAUL RAZOUS. *Ciment* (France) Jan. 1931, V. 36, No. 1, p. 13-8; No. 2, p. 59-61.—A description of the properties and list of the different companies and plants making the following cements is given: natural, Roman, artificial (portland), high early strength, alumina, slag (using lime), grappiers (from flint nodules), mixed, white, iron (70 per cent portland clinker with 30 per cent granulated blast furnace slag), and blast furnace cement (contains less clinker than iron cement).—F. O. ANDEREGG

The new cement plant at Neuwied. C. E. PERES. *Tonind. Ztg.* (Germany), March 5, 1931, V. 55, No. 19, p. 275-7.—General plant description.—F. O. ANDEREGG

Testing protective coatings for concrete. P. MECKE. *Tonind. Ztg.* (Germany), March 16, 1931, V. 55, No. 22, p. 322.—To determine the solvent accurately in bituminous preparations 5 g. is placed in a small foil box containing a small roll of gauze. After drying at 100° C. for one hour with the cover removed, the bitumen is distributed over gauze. Then dry to constant weight at 110°. To test the resistance against chemical effects a mortar specimen is made 5x5 in. and a cylinder cemented to it with neat cement. After the cement hardens three coats are applied and the cylinder filled with the solution to be tested.—F. O. ANDEREGG

A new shaft kiln cement plant. HORST LAEGER. *Tonind. Ztg.* (Germany), March 16, 1931, V. 55, No. 22, p. 322-5.—Shaft kiln cement plant erected in Ankara (Angora) with rotating grate.—F. O. ANDEREGG

The different kinds of lime and their handling. F. EISEMANN. *Tonind. Ztg.* (Germany), March 19, 1931, V. 55, No. 23, p. 339-41.—A general description.—F. O. ANDEREGG

Cement synthesis in the four component parallelogram and the degree of lime saturation according to Kühl. M. SPINDEL. *Tonind. Ztg.* (Germany), March 12, 1931, V. 55, No. 21, p. 305-7.—Parallelogram show-

ing composition of cements in terms of lime, silica, alumina and iron oxide can also be used for Kühl's degree of lime saturation.—F. O. ANDEREGG

Industrial heating with ground coal in the mineral industries. J. DEFORGE. *Rev. materiaux construction trav. publics.* (France) Dec., 1930, No. 255, p. 469-73; Jan., 1931, No. 256, p. 5-10; Feb., 1931, No. 257, p. 49-53; March, 1931, No. 258, p. 101-5.—A careful analysis giving advantages and disadvantages.—F. O. ANDEREGG

Modern cement burning. HEINRICH LUFTSCHITZ. *Tonind. Ztg.* (Germany) Feb. 12, 1931, V. 55, No. 13, p. 184-6.—In Schröder shaft kiln dry raw material falls through a shaft kiln heated by coal dust falling through an annular space outside. Also the Rigby patent is used for spraying slurry into a kiln.—F. O. ANDEREGG

Determining the proportions of mortars and concretes. LUDWIG SCHUSTER. *Tonind. Ztg.* (Germany) Feb. 23, 26, 1931, V. 55, No. 16, 17, p. 224-5, 243-4. Examples are given where composition of old mortars and concretes are determined by making analyses for soluble silica, lime, etc. If possible, an analysis of aggregates simplifies solution of problem.—F. O. ANDEREGG

The new cement plant at Rodaun. K. A. GOSLICH. *Tonind. Ztg.* (Germany), March 16, 1931, V. 55, No. 22, p. 317-20.—Description of the erection of a new, dry process cement plant on site of the old one.—F. O. ANDEREGG

German specifications for alumina cement. HUGO VIERHELLER. *Tonind. Ztg.* (Germany), March 16, 1931, V. 55, No. 22, p. 325-6.—Fineness: not more than 2 per cent on the 75 and 15 per cent on 180 mesh sieve. Tests to be made at 15 to 20° C. Storage of specimens 24 hr. in damp closet and then under wet cloths. Minimum strengths are: at 24 hr., at 28 da. wet and at 28 da. combined storage: compression, 400, 500, 600 and tensile; 25, 30 and 40 kg. per sq. cm.—F. O. ANDEREGG

Rapid determination of magnesia in portland cement. CH. ROGOZINSKI. *Tonind. Ztg.* (Germany), March 23, 1931, V. 55, No. 24, p. 355-6.—After removing the silica, *N* NaOH is added till a precipitate forms and the supernatant liquor is clear. Filter into an excess 0.2 *N* HCl and titrate back with 0.2*N* NaOH and phenolphthalein—F. O. ANDEREGG

Measures for securing cement of uniform quality. W. SACH. *Tonind. Ztg.* (Germany), March 9, 1931, V. 55, No. 20, p. 291-3.—Proper feeding, weighing and mixing, obtained with suitable automatic apparatus are useful in securing uniform quality.—F. O. ANDEREGG

The uniformity of concrete and its control on the job. FRITZ EMPERGER. *Tonind. Ztg.* (Germany), March 30, 1931, V. 55, No. 26, p. 382-3—Cubes and beams are made and broken at seven days.—F. O. ANDEREGG

Alumina cement. M. KAUCHTSCHISCHWILI. *Siemens-Z.* 1930, No. 9, 10; *Tonind. Ztg.* (Germany), Dec. 18, 1930, V. 54, No. 101, p. 1565-7; No. 102, p. 1585-6.—Description of general properties and of manufacture.—F. O. ANDEREGG

Studies on high-iron oxide cements—Part 1. SHOICHIRO NAGAI AND KEI-ICHI AKIYAMA. *Kogyo Kwagaku Zasshi, J. of Soc. Chem. Ind.* (Japan), Feb., 1930, V. 33, Supplemental Binding No. 2, p. 47-9B.—Two high-iron oxide cements, one of the iron cement type and one of Kuhl cement type were prepared of two pozzuolanas, analyses of which are given and limestone. Composition and properties of burned clinkers were studied and compared with commercial products. Normal and small-piece testing method were used for determination of compressive strength. (cf. *Kogyo Kwagaku Zasshi, J. of Soc. Chem. Ind.* (Japan), 1930, V. 33, p. 286-90, 421-8; JOURNAL A. C. I., Feb., 1931, V. 2, No. 6, *Abstracts* Sect., p. 162.)—A. E. BEITLICH

Cement-mill expansion program reflects vision of designing engineers. W. E. TRAUFFER. *Pit and Quarry,* March 11, 1931, V. 21, No. 12, p. 67-78.—Improvements in plant of Keystone Portland Cement Co., at Bath, Pa., include enlargement of stone storage, a second overhead traveling crane,

two raw-grinding and two finish-grinding mills, additional slurry silos, two kilns and stacks, enlargement of the coal-pulverizing equipment, additional cement-storage silos and packhouses, and enlargements to crusher, mill and kiln buildings. Raw mills are opposite stone storage, coal mill is opposite coal storage, discharge ends of kilns and finish mills are opposite clinker storage, and slurry silos are between raw mills and feed ends of kilns. All raw material comes from one quarry and as sent to mill is practically correct composition for high grade cement.—A. J. HOSKIN

Microscopical, optical and X-ray investigations concerning the question: "What is alit?" I. WEYER. *Zement* (Germany), Jan. 29, 1931, V. 20, No. 5, p. 96-100.—Alit, separated from commercial clinker, was found to contain considerable amounts of alumina. This fact led to beliefs that tricalcium aluminate can enter into combination with tricalcium silicate. In experiments made to study problem, various mixtures of pure tricalcium silicate and tricalcium aluminate were mixed and burned several times at different temperatures and products investigated by X-ray analysis. None of mixtures showed any characteristic lines besides lines for tricalcium aluminate and tricalcium silicate. In mixtures with only 6.89 per cent tricalcium aluminate (16:1), it was impossible to detect this compound. Microscopic studies showed that a recrystallization of tricalcium silicate takes place in such melts which fact does not change its optical characteristics.—A. E. BEITLICH

Petrographic investigation of fused high alumina cements. KATSUZO KOYANAGI. *Kogyo Kwagaku Zasshi, J. of Soc. Chem. Ind.* (Japan), Sept., 1930, V. 33, Supplemental Binding, No. 9, p. 352-8B.—Investigations and experiments by Gruen, Dyckerhoff and Biehl in studies of chemical constitution of high alumina cements are described. Efforts were made by author to prepare synthetically a melt of composition: 47 per cent CaO, 44 per cent Al_2O_3 and 9 per cent SiO_2, which is similar to French Ciment fondu. After different heat treatments thin sections were studied under microscope and optical properties were determined. Furthermore melts of following compositions were prepared: $3CaO.5Al_2O_3$, $CaO.Al_2O_3$, $3CaO.Al_2O_3$ and $5CaO.3Al_2O_3$ and microscopically investigated.—A. E. BEITLICH

Studies of the method by Lawrence Smith for the determination of alkalies. CURT PRUSSING. *Zement* (Germany), April 16, 1931, V. 20, No. 16, p. 360.—The method for determination of alkalies which was proposed for German standard specifications for chemical analysis of portland cement (Burchartz, *Zement* (Germany), March 19, 26, 1931, V. 20, No. 12-13, p. 258-60, 290-2), was checked and it was found that temperature for ignition of alkalies is too high. Great amounts of alkalies are volatilized. Mixtures of sodium chloride, potassium chloride and ammonium chloride were ignited at 932 to 1922° F. and loss on ignition was determined. Author proposed heating of sample in electric crucible furnace provided with a rheostat to regulate temperature between 700 and 750° F.—A. E. BEITLICH

A mixed cement of low solubility of portland cement and arsenic trioxide. DONOVAN WERNER AND STIG GIERTZ-HEDSTROM. *Zement* (Germany), April 23, 1931, V. 20, No. 17, p. 384-8.—Investigation of possibilities of use of a mixture of portland cement and arsenic trioxide yielded following: Mixed cement with 30 per cent As_2O_3 is quick setting (5 minutes); it can be made normal setting by heating in closed container. Compressive and tensile strengths are lowered by additions from 10 to 15 per cent As_2O_3; with increasing additions strength increases too and reaches maximum with 30 per cent. Above 30 per cent strength decreases again. Strength is always slightly lower than strength of pure cement. Solubility of lime of portland cement is greatly reduced by additions of As_2O_3. Best composition is 70 per cent portland cement and 30 per cent arsenic trioxide which produces, after heating, a very slightly soluble normal setting cement with strength properties above limits of specifications.—A. E. BEITLICH

The determination of the uncombined lime. Supplemental discussion of the glycerol-tartaric acid method of H. Rathke. K. SCHINDLER. *Zement* (Germany), April 23, 1931, V. 20, No. 17, p. 389-90.—A new procedure is described which overcomes difficulties and inaccuracies of method by Rathke who modifies Emley's method by using tartaric acid instead of ammonium acetate for titration of uncombined lime. Greatest source for errors is tendency of calcium glycerate to crystallize before all calcium oxide is dissolved thus preventing complete solution. It affects especially standardization of tartaric acid. Procedure is same for cement and similar materials.—A. E. BEITLICH

Investigation of portland cement and its constituents by means of measurements of vapor pressure. Part 2. F. KRAUSS AND G. JOERNS. *Zement* (Germany), April 2, 9, 1931, V. 20, No. 14, 15, p. 314-7, 341-3.—Preliminary investigation and experiments were reported in previous article (*Zement* (Germany), Nov. 6, 1930, V. 19, No. 45, p. 1054-5; JOURNAL A. C. I., Feb. 1931, V. 2, No. 6, *Abstracts*, p. 164). Work was continued and vapor pressure curves determined for gypsum, calcium carbonate, calcium hydroxide and hydrates of silica, alumina and ferric oxide. Synthetic melts of tricalcium silicate, tricalcium aluminate and compound $8CaO.2SiO_2.Al_2O_3$ were prepared from pure raw materials and hydrated. Products of hydration were decomposed and characteristics of vapor pressure curves were studied. Similar tests were conducted with portland cement. Work will be continued.—A. E. BEITLICH

Contribution to the hardening problem of portland cement. HANS KUHL. *Zement* (Germany), March 12, 1931, V. 20, No. 11, p. 234-9.—Contrary to Tippmann's theory, (cf. *Zement* (Germany), Dec. 25, 1930, V. 19, No. 52, p. 1225-34) chief products of hydration of portland cement are calcium hydrosilicates, not calcium hydroxide and silica gels. Cements of normal consistency do not have a high viscosity. Special consideration is given to description of 2 different modifications of calcium hydroxide. Existence of amorphous calcium hydroxide with a specific gravity of 2.08 is denied. Experiments for preparation of this form were made according to Tippmann's directions but with negative results. Cement was mixed with water and with weak and saturated gypsum solutions. Products of hydration were examined under microscope at frequent intervals. No distinct difference could be detected. Author obtained small crystals of $Ca(OH)_2$ from calcium oxide and water which formation was claimed to be impossible by Tippmann. Statement that 2 modifications of calcium hydroxide are chief constituents in hardening process is attacked. This property is attributed to calcium hydrosilicates. The microscopic method used by Tippmann is criticized. Theoretical deductions and experimental findings do not harmonize.—A. E. BEITLICH

The effect of different kinds of gypsum on setting of cements. KATSUZO KOYANAGI. *Zement* (Germany), March 5, 1931, V. 20, No. 10, p. 215-7.—In experiments with a portland cement clinker and gypsum, hemihydrate, dehydrated anhydrite and natural anhydrite, retarders were either ground together with clinker or fine ground materials were mixed together in a laboratory size mixer. Setting properties of mixtures with 0 to 10 per cent SO_3 were determined. A certain percentage was found where retarding effect is greatest. This is 5 per cent SO_3 for natural anhydrite, 2 per cent for gypsum, 1.5 per cent for hemihydrate and 1.2 per cent for dehydrated anhydrite. Effect of retarders was greater when mixed with fine clinker than in case where both were ground together. Experiments A. Heiser (cf. *Zement* (Germany), July 1930, V. 19, No. 29, p. 679-80; JOURNAL A. C. I., Oct. 1930, V. 2, No. 2, *Abstracts*, p. 34), yielded entirely different results. His tests were made on large scale under different temperature conditions and his opinion is supported by Grimm, Forsen and Tippmann.—A. E. BEITLICH

Effect of storage on properties of standard cements. RICHARD GRUEN AND H. MANECKE. *Zentralblatt der Bauverwaltung* (Germany), 1930, V. 50, p. 485, reviewed in *Zement* (Germany), Jan. 22, 1931, V. 20, No. 4, p. 86.

—Storage of cements at 18° F. resulted in decrease of about 8 per cent in 7-day tensile strength and increase of about 20 per cent in 3-day compressive strength. Storage in closed room had no harmful effect on strength properties. Careless storage in single sacks in open shed led to decrease of tensile and compressive strength, especially when lumps were not removed by sieving. Greatest losses after 3 months storage were 17 per cent for tensile strength and 14 per cent for compressive strength.—A. E. BEITLICH

Loss in strength of cement through storage. WALTER OBST. *Betonwerk*, March 29, 1931, V. 19, No. 13, p. 173.—Cement that does not deteriorate in storage is unknown, but fresh cement is not always constant in volume and a period of storage is helpful. Storage in warehouse in a thick layer and periodic turning over by plowing does much to prevent "efflorescence." This method also increases strength. For best practice cement should not be stored more than three months and never longer than nine months. Twelve months decreases strength up to 30 per cent. Storage rooms should be free of draft, cement should be placed on planking raised up from floor and bags of cement should be placed free of wall and piled not higher than 10 high. Paper bags are better than cloth bags for keeping cement in good condition.—H. FRAUENFELDER

Changes of setting time of portland cement. HELLMUT WEITHASE. *Zement* (Germany), Feb. 26, 1931, V. 20, No. 9, p. 187-92.—Thirty references are given to papers dealing with changes in setting time of portland cement during storage. Phenomena are explained in many different ways. To clear this question comprehensive tests with 55 cements were undertaken. Cement was spread in thin layers of about 1 or 2 in. and setting times were determined within very short intervals of storage. Certain very fine cements show earlier initial set in air storage but retarded final set. Changes seem to be caused in the first place by chemical composition, especially lime content of cement and also by effect of carbon dioxide of air on cement.—A. E. BEITLICH

The Rigby-spray method in cement industry. S. I. M. AULD. *Zement* (Germany), Feb. 12, 1931, V. 20, No. 7, p. 142-4.—Greater heat economy and increased efficiency is obtained by spraying slurry into kilns by means of compressed air. Great surface of dispersed fine materials facilitates drying. Kiln gas temperature is lowered causing less coal consumption and smaller radiation losses. Calcination zone of kiln is as long as in ordinary kiln. Only 26 per cent of total length is used for drying. Nozzles under pressure of 5 atmospheres can be easily replaced without interruption of operation and at low costs. Installation of fan is advisable to compensate for decreased draft on account of lower temperature of kiln gases.—A. E. BEITLICH

The last word in the alit problem. A. GUTTMANN AND F. GILLE. *Zement* (Germany), Feb. 12, 1931, V. 20, No. 7, p. 144-7.—After studying latest research results of American and German investigators on subject of existence of tricalcium silicate and presenting data on X-ray diffraction patterns in several tables, authors draw following conclusions. (1) No doubt exists about existence of tricalcium silicate. (2) Alit, chief constituent of high lime portland cements, is neither a dicalcium silicate which is rich in free lime (Dyckerhoff), nor a solid, solution of a high lime aluminate, (Jaeneckeit), and tricalcium silicate (Kuehl), nor a solid solution of chiefly tricalcium silicate and tricalcium aluminate (Guttmann and Gille), nor a solid solution of Jaeneckeit and dicalcium silicate (Jaenecke), nor is dicalcium silicate chief constituent of alit (Nacken), but alit is tricalcium silicate. (3) Part of alumina is combined as celit (chiefly $4CaO.Al_2O_3.(Fe,Mn)_2O_3$). Remaining part is present as tricalcium aluminate and partly as $5CaO.Al_2O_3$.—A. E. BEITLICH

Fine cement. A. B. HELBIG. *Zement* (Germany), Jan. 22, 1931, V. 20, No. 4, p. 75-8.—Contrary to findings of Hans Kühl and A. Hauenschild, cement strength increases with increasing fineness, especially in early ages. Decrease in strength which was observed by above investigators in cases of extremely fine cements, is due to a partial hydration of fine particles by moisture of air in air separator. Commercial cements were separated into several fine fractions

by means of a large scale air separator. Tables show fineness of separation, water for normal consistency and compressive and tensile strength data up to 28 days in water and combination storage. Fineness affects water permeability. Case is cited where fine grinding increased strength in ratio 1:1.9 while water permeability was decreased in ratio 56:1. Diagram shows relation between particle size of cement and best suitable diameter of steel balls in mill. —A. E. BEITLICH

Fine cement. HANS KUHL. *Zement* (Germany), Feb. 19, 1931, V. 20, No. 8, p. 169-70.—In answer to article by A. B. Helbig in *Zement* (Germany), Jan. 22, 1931, V. 20, No. 4, p. 75-8, author states that Helbig did not work with cements of such extreme fineness and therefore did not notice a decrease in strength in very fine range. Inner surfaces of cements, used by Helbig, were calculated by means of formula derived by Kuhl and Tokune. Finest cement had surface of 216.5 sq. in. A drop in strength was observed only in cases of cements with inner surfaces of 500 sq. in. and higher. Cements investigated by author were not affected by moisture; air for separation was absolutely dry.—A. E. BEITLICH

New Mexican cement plant serves west coast territory. *Concrete*, March, 1931. V. 38, No. 3, p. 77.—Wet process cement plant is nearing completion at Hermosillo, Sonora, Mexico. Present capacity is 500 barrels per day (one 8 by 150-ft. kiln), provisions being made for increasing capacity at any time. Raw materials are stone and clay. There are two gyratory crushers (one 12 in. and one 4½ in.), and two 6 by 22-ft. compartment mills (one for raw and one for finishing grinding). Power is furnished by three 360 h. p. Diesel engines direct-connected to Westinghouse generators.—V. E. BUTLER

Technical progress reports. Volume 25. Cement. "Technische Fortschritts Berichte. Band 25. Zement." F. WECKE, 1930, Th. Steinkopff, Dresden and Leipzig, (Germany), RM. 6.00. Reviewed in *Zement* (Germany), Feb. 12, 1931, V. 20, No. 7, p. 156.—Valuable data are presented on portland cement, raw materials, manufacture and testing, and high early strength cements, special cements and blast furnace slag cements are discussed. Numerous literature references, complete up to 1929 aid study of progress and problems in cement manufacture and cement chemistry. Statistical data are furnished on import and export trade since 1900.—A. E. BEITLICH

The "Delta" rocker chute. H. WALTER. *Zement* (Germany), Feb. 26, 1931, V. 20, No. 9, p. 201-2.—New improved rocker chute is especially suitable for transportation of large amounts of dusty, pulverized and broken materials, Design and construction make operation very economical. Machine is applicable for conveying of hot clinker in cement industry.—A. E. BEITLICH

The degree of lime saturation. HANS KUHL. *Zement* (Germany), Feb. 5, 1931, V. 20, No. 6, p. 123-5.—In criticism of proposed changes of "degree of lime saturation" by Hess (cf. *Zement* (Germany), Jan. 8, 1931, V. 20, No. 2, p. 28-32; JOURNAL A. C. I., April, 1931, V. 2, No. 8, *Abstracts*, p. 214), author agrees with proposal to express degree of lime saturation by a number 100 times as big as previously used but he criticizes attempts of Hess to make changes in derived equation, especially to give numbers with too many decimal places. Latter procedure would give a false impression of accuracy of calculation method.—A. E. BEITLICH

New cement plant in Dumesnil (Argentina). *Zement* (Germany), Feb. 5, 1931, V. 20, No. 6, p. 134.—At modern wet process portland cement plant recently completed in close vicinity of limestone quarries near Dumesnil, aerial cable ways deliver limestone and clay in cars. Clay slurry is ground together with limestone. Material passes through kiln bins into 9 rotary kilns, 223 ft. long and 9.8 and 11.8 ft. in diameter. Each kiln produces 220 tons of clinker in 24 hours. Fuel consumption is 44 tons of crude oil. Finished product is pumped to cement storage bins. Plant is equipped with very modern cement laboratories, machine shops, water tower, cooling tower and modern power house.—A. E. BEITLICH

Finding undeveloped sources of fuel for cement plants. E. T. ELLIS. *Concrete*, Feb., 1931, V. 38, No. 2, p. 91.—Certain so-called low grade fuels are apt to be overlooked by cement manufacturers, but can, if manipulated in certain easy ways, be utilized advantageously for burning, either alone or combined with coal and other materials usually employed. The compositions and names of these many materials vary widely in different parts of the world, but analyses in many instances are available, and by examining these together with materials themselves it is possible to judge whether any offer of such materials should be declined or accepted. Materials discussed are: Anthracite culm, anthracite slush or silt, "batts" from coal cleanng dumps, colliery slurry, colliery smudge, refuse from tipple picking tables, steam duff, tip breeze, and washery waste.—V. E. BUTLER

Discussion of the new proposed German standard specifications for reinforced concrete. OTTO GASSNER. *Zement* (Germany), Feb. 26, 1931, V. 20, No. 9, p. 198-200.—Changes and additions to tentative specifications of the German Committee for Reinforced Concrete, Part A, Specificatons for Construction of Structures of Reinforced Concrete are criticized. Definition of standard cement is slightly changed and high early strength cements are included. Natural cements are not mentioned. Exact control of gradation of aggreates, especially for important structures, wet concrete and under-water cast concrete are demanded. Use of broken volcaneous materials and pumice are admitted as aggregates. More consideration is given to impurities of aggregates. No boiler cinders are allowed for reinforced concrete. In structures exposed to high temperatures reinforced concrete must contain aggregates with small expansion coefficient and low heat conductivity. Quartzy aggregates should not be used in chimney construction. Insufficient definition of degree of impurity of mixing water is criticized.—A. E. BEITLICH

Only active cement plant in Arkansas. J. F. KAUFMAN. *Rock Products*, March 28, 1931, V. 34, No. 7, p. 41.—Distinguishing feature of operation of Arkans Portland Cement Co.'s mill at Okay, Ark. is filtering of slurry in three 12-disk filters with 7200 sq. ft. filtering surface. Without filtration the slurry, made from chalk and clay, had a moisture content of 48-50 per cent and was hard to handle because of viscous nature. Filtration reduced moisture to 28½-29 per cent. Filter cake is fed to kiln by a Bessemer feeder. Capacity of filter depends on temperature of slurry. Heat of waste gases brings the water to 150° F. Cast iron lifters in the kiln keep the slurry moving forward and prevent the formation of mud rings.—EDMUND SHAW

Contribution to the question of kilns for the manufacture of fused cements. E. SCHIRM. *Zement* (Germany), Feb. 5, 1931, V. 20, No. 6, p. 118-23.—Various kinds of high alumina cement kilns have their advantages and disadvantages (1) In shaft kiln with water jacket, raw mixture consisting mostly of limestone and bauxite becomes pasty which fact causes considerable difficulty. (2) Improved shaft kiln has separate horizontal fusion chamber. Material in vertical part is only preheated and not fused. (3) Still better is kiln so constructed that pasty zone is prevented. (4) Another shaft kiln consists of 3 different chambers. Material is heated and partly decomposed in top chamber, then fed to second section on a water cooled grate. (5) Greatest difficulty with rotary kiln is formation of back rings which may block entire kiln. (6) An improvement was developed in France by installing a longer kiln head with hottest part of flame where material leaves kiln. (7) Better heat economy is obtained by installing a recuperator. (8) Kiln has been designed in which bauxite and limestone are heated separately in 2 concentric tubes. Heated materials are emptied into hearth furnace where mixture is burned completely. —A. E. BEITLICH

Chemical reactions in the setting of cement. LINCOLN T. WORK AND FRANKLIN P. LASSETER. *Concrete*, March, 1931, V. 38, No. 3, p. 81-86, No. 4, p. 89-92, No. 5, p. 79-84.—Investigation of chemical reactions that take place during setting and hardening of portland cement is abstracted by the authors.

In studying state of combination of water, following methods were tested: 1. Extraction with absolute alcohol. 2. Distillation using benzol, toluol and xylol. 3. Vacuum drying. 4. Oven drying in dry air at 90, 105 and 130 deg. C. The test of oven drying at 105° C. was chosen as standard. Total water was determined at 850° C. Under those conditions a small amount of moisture will remain, but calcium sulfate should not be decomposed appreciably. Therefore, difference representing combined water should be essentially correct. Ammonium acetate method for lime in clinker has been adapted to measure hydrated lime in a set cement. Samples with varying water-cement ratios using each of the compounds tricalcium aluminate, tricalcium silicate, and β dicalcium silicate, and four commercial cements, were studied to ascertain nature of chemical reactions and rate of hydration and hydrolysis during setting and hardening. Tricalcium aluminate hydrates to $3CaO.Al_2O_3.6H_2O$ and this on calcination yields lime and an apparent residue of $5CaO.\ 3Al_2O_3$. This hexahydrate can be partially dehydrated in vacuum at 240-250° C. With water-cement ratios of 0.5 and greater, tricalcium aluminate was practically completely hydrated to hexahydrate in 28 days. Tricalcium silicate reacts both by hydration and hydrolysis. During early stages of hydrolysis approximately one molecule of water combines with silicate for each molecule of lime liberated. Beta dicalcum silicate was shown to react chiefly by addition of water and released very little lime for several months. Pure compounds and cements yielded a typical curve for percentage of combined water against water-cement ratio. Starting at the origin, values of combined water rose with water-cement ratio up to a ratio of 0.2 to 0.4, after which they became practically horizontal. In case of the aluminate, reaction at low water-cement ratio consumed all of the water, but that was not found to be the case with other pure compounds or with cements. Hydration was rapid with aluminate, slower with tricalcium silicate and very much slower with dicalcium silicate. Tricalcium aluminate yielded no lime in setting. Tricalcium silicate yielded lime more or less similar in amount to combined water value and beta dicalcium silicate yielded but small quantities of lime up to three months. Combined water values for cements were similar to those for tricalcium silicate but rate of hydration varied directly with fineness. Lime values were somewhat similar, save for a dip in the curve at low water-cement ratios which appears to be due to selective hydration of aluminate. Comparison of hydration and hydrolysis of cements was made with strength of a standard concrete using same cements at water-cement ratio of 0.55. Fine cements reacted more completely in early stages and developed high strength. Coarse cement reacted slowly at first but for a longer time. Later reaction did not develop an equivalent strength.—V. E. BUTLER

Constitution of portland cement studied by X-ray method. L. T. BROWNMILLER AND R. H. BOGUE. *Concrete*, Feb. 1931, V. 38, No. 2, p. 85, March, 1931, V. 38, No. 3, p. 89.—Objectives in research were (1) to obtain additional information on theories established by other investigators, and (2) examination of a large number of commercial clinkers by x-ray and chemical methods to find out exactly what compounds could be positively identified in each and nature of agreement between such x-ray analysis and constitution as computed from chemical analysis. It was necessary to determine efficiency of x-ray method to decide pattern of each compound in presence of other compounds of cement. An examination of composition $3CaO + SiO_2$ proved that $3CaO.SiO_2$ exists and can be formed by heating together, under proper conditions, of a properly proportioned mixture of lime and silica. An examination of the system $3CaO.SiO_2$—$2CaO.SiO_2$—$3CaO.Al_2O_3$ shows that solid solution does not occur between either of above silicates and aluminate in large amounts. Mixtures at equilibrium contain only those three compounds. In commercial cement clinkers free CaO was not found by x-ray method. Study of identification of that compound indicates that a percentage of CaO of 2.5 could be recognized. Therefore, it is demonstrated that free CaO is not commonly present in commercial clinkers in amounts as high as 2.5 per cent. The x-ray

diffraction patterns of 28 commercial portland cement clinkers, representing many types of raw material and processes of manufacture—both domestic and foreign—were obtained. Results obtained by x-ray methods define major constitution of portland cement clinker and indicate most abundant constituents are tricalcium silicate and beta dicalcium silicate; that there are normally present, in addition, tricalcium aluminate, tetracalcium alumino ferrite and magnesia; and that free CaO is not normally present in amounts as great as 2.5 per cent.—V. E. BUTLER

Free lime in portland cement clinker and soundness of cement. KATSUZO KOYANAGI. *Rock Products*, March 28, 1931. V. 34. No. 7, p. 74.—There are two opinions of free lime in cement clinker. Rohland thinks unsoundness comes from lime that is neither dissolved in other constituents nor chemically combined, and Kuhl thinks that lime in cement is never free and that unsoundness comes from "explosive grains" containing excess lime in solution or combination. Japanese cement burners test clinker by touching it to the tongue. If saliva is absorbed quickly clinker is thought unsound. To test this, Emley's method of determining free lime, as modified by Rathke has been used by the author in tests of sound and unsound clinkers which included determinations of porosity and free lime. Porosity was determined by immersing in water-free turpentine oil for 24 hr. and then boiling ½-hr. and cooling and weighing. Soundness was determined by water test, boiling and a modification of LeChatelier's test. Further research showed clinkers could have low porosity and high free lime content. These were hard burned clinkers with high iron oxide content except one with extraordinarily low lime content and overburned. In mixtures of sound with unsound cement, with free lime running from 0.45 to 0.81 per cent, samples were sound; from 0.99 to 1.88 per cent, samples were unsound, increasingly so as free lime increased. A third series of tests showed effect of storing unsound cement on paper in laboratory so that free lime had a chance to carbonate. The temp. was 73-86° F. and the moisture, 80-100 per cent normal. In 3 da. free lime fell from 2.44 per cent, to 1.49 per cent and in 40 da. to .30 per cent. All samples taken at 20 da. and after were sound. At a fineness of 4 per cent on a 4900-mesh (metric) sieve cement becomes unsound in boiling test when free lime exceeds 1 per cent and unsound to both boiling and water tests when it exceeds 2.2 per cent. Whether this free lime is absolutely free or is combined in explosive grains is not known exactly, but it is certain that it affects soundness of cement very much.—EDMUND SHAW

A tentative modification of the free lime method. H. R. BRANDENBURG. *Rock Products*, March 14, 1931, V. 34, No. 6, p. 68.—Use of barium chloride as a reagent to increase solubility of CaO in glycerol-alcohol mixture in determining free lime is suggested. The $BaCl_2$ is made anhydrous by holding at 140-150° C. for several hours. Then it is cooled, ground and stored in a desiccator. Tests were agitated on the base of a Ro-tap screening machine, to which had been clamped a sheet metal holder that would take six flasks. Standards were run on freshly calcined CaO, from .05 to 25 g., with and without $BaCl_2$. Solution of CaO was extremely rapid, permitting additions of acetate solution to be made at 2 to 5 min. intervals, care being taken not to run in an excess. CaO values were found to be a trifle higher than with standard method. On materials requiring from 2.0 to 2.5 cc. of the acetate solution, time with $BaCl_2$ varied from 25 to 40 min. as against 2½ to 4 hr. by the standard method. Method has been used successfully on clinkers, hydrated limes and plasters.—EDMUND SHAW

Researches on the rotary kiln in cement manufacture. Part 14. Flame temperatures obtained in practice in the cement rotary kiln. GEOFFREY MARTIN. *Rock Products*, March 14, 1931, V. 34, No. 6, p. 41.—Actual temperatures observed by the B. P. C. R. A. by optical pyrometer were 2759, 2692, 2536 and 2835° F. Prof. Nacken found a temperature of 2606° F. and E. C. Soper 2587° F. with the same instrument. Prof. Nacken's figures are taken as the mean flame temperature in ordinary kiln. It is assumed that

11.278 lb. combustion gas is produced by burning 1 lb. coal in t sec. In insulated enclosure, with 10.478 lb. air preheated to 400° F. gas will rise 3977° F. In the actual kiln so much heat is lost by radiation, conduction and convection that temperature is reduced to 2600°. Heat is lost by (1) external radiation, (2) radiating from hot flame to cooler parts of kiln and (3) communicating by conduction and convection to material in clinkering zone. (1) is waste but (2) and (3) can be usefully employed under limitations. At clinkering temperature clinker tends to evolve heat. In practice amount of clinker turned out of flame sinking through different temperatures can be calculated.—EDMUND SHAW

Researches on the rotary kiln in cement manufacture. Part 15. Weight of clinker producible using combustion gases of different flame temperatures and supplying 10.478 lb. air per 1 lb. of standard coal burned. GEOFFREY MARTIN. *Rock Products*, March 28, 1931, V. 34, No. 7, p. 68.—Main heating agent in kiln is hot gases into which powdered coal oxidizes. Each pound coal yields 11.278 lb. gas which, in the ordinary cement kiln, starts at 2600° F. and imparts its heat to material as it travels. The kiln may be divided into two parts, A where the temp. is above 1481° F. and B where it is below this. Limestone and chalk will decompose only in A. Heat in B is useful in drying and heating materials preparatory to clinkering in B. Quantity of clinker formed is measured by the amount of heat absorbed by the material in A between 1481° F. and the clinkering temp., 2498° F. This quantity of heat, Q equals $11.278 \times S \times (T - 1481°) \times$ B.t.u., where T is the max. temp. and S is specific heat. To form 1 lb. clinker requires 918.6 B.t.u., so weight of clinker W, formed by burning 1 lb. standard coal to its equivalent of 11.278 lb. gas equals Q, divided by 918.6. If coal is burned in t sec., amount of clinker produced in 1 sec. is $\frac{W}{t}$. As ideal kiln would require only 6.36 tons coal, ordinary kiln making 100 tons clinker for 28 tons standard coal is only 22.7% efficient. Computed results show that heating in kiln is by hot gas and that clinker output is measured by heat loss of gas as it travels down kiln. —EDMUND SHAW

The upper SO_3 limit in portland cement. F. O. ANDEREGG. *Rock Products*, Feb. 28, 1931, V. 34, No. 5, p. 76.—Better retardation of finely ground high-early-strength cement is reason for adding more gypsum to clinker than has been permitted in past. Question arises as to safe upper limit of SO_3 since excess gypsum is known to reduce durability of cement, probably by crystal growth. Tests were made with cement flour, air-separated so practically all particles were below 10 microns in diameter. Oversize was reground and separated to give a cement containing a fraction less SO_3. When cement is gaged with water a low sulphate form may be present at first but it changes over to more stable form which may grow into crystals large enough to be identified under microscope. In view of the test results the proposed A. S. T. M. specifications limiting SO_3 to 2½ per cent in early-strength cements appears conservative, but greater amounts are undesirable. Alumina content of clinker should be kept within reasonable limits. From a study of the rate of hardening of specimens made from cement flour it is thought that indurating reactions of silica gel play important role in hardening of this cement.—EDMUND SHAW

MISCELLANEOUS

Separation of calcium and magnesium by molybdate method. R. C. WILEY. *Ind. Eng. Chem.*, Analytical Edition, April, 1931, V. 3, No. 2, p. 127-9.—Calcium molybdate is quite insoluble in a solution that is nearly neutral. Calcium may be determined accurately by precipitating as molybdate. Presence of residual ammonium molybdate in washings from calcium molybdate does not prevent precipitation of magnesium as magnesium ammonium phosphate, and presence of ammonium salts does not interfere with determination of calcium as molybdate. Calcium and magnesium may be

determined in much less time when molybdate method for calcium is used than when calcium is precipitated by the oxalate method.—ROY N. YOUNG

Protective coatings. KARL MEYER. *Zement* (Germany), Jan. 29, 1931, V. 20, No. 5, p. 109-10.—It is claimed that protective media such as paraffine and asphalt, proposed by Goslich (cf. *Zement* (Germany), June 1930, V. 19, No. 24, p. 567-8; *Journal A. C. I.*, Oct. 1930, V. 2, No. 2, *Abstr.*, p. 38), do not give satisfactory service for protection of concrete and reinforced concrete. Better results can be obtained with modern cold asphalt paints. Goslich claims that coatings consisting of hydrocarbons (paraffines) are highly resistant in aggressive waters and moist air. Several examples are cited where such media have been used with great success.—A. E. BEITLICH

Pulverized coal fuel in the mineral industries. J. DEFORGE. *Rc. materiaux construction trav. publics*, (France), December 1930 to March 1931.—Conclusions drawn upon discussing in detail economy of pulverised coal as a fuel are: Advantages (a) more complete evolution of heat corresponding to calorific value of the fuel; (b) possibility of utilizing inferior grade fuels, not acceptable for use otherwise. (c) simplification of firing; instantaneous ignition and extinction; a specially valuable ease of operation under certain conditions of installation. Disadvantages (a) accident risk; (b) flue dust difficulties; (c) the high cost of installation. Accidents can be greatly reduced in using adequate precaution. Special devices cope with flue dust problem. High initial cost is frequently more than compensated through economies in using a cheaper fuel or through lower fuel consumption. Though in every case, a study should be made of special conditions pertaining to installation in question, French industries should take advantage of this most rational method of utilizing coal.—M. A. CORBIN

Mechanism of combustion of individual particles of solid fuels. DAVIS F. SMITH AND AUSTIN GUDMUNDSEN. *Ind. Eng. Chem.*, March, 1931, V. 23, No. 3, p. 277-285.—Descriptions in detail of unique apparatus and methods employed in a fundamental study of combustion of solid fuel are included. Effects of varying particle size, air velocity, temperature and humidity on rate of combustion of solid fuel under carefully controlled conditions have been investigated and considerable light is thrown upon the mechanism of these important reactions. Briefly the procedure consists of heating a weighed sphere of fuel to the desired temperature in inert gas, suddenly blasting the particle with an air stream of given velocity and temperature for a very short interval of time, quickly quenching the particle in inert gas, again weighing to determine amount of reaction, and carefully obtaining records of particle surface temperature during combustion. Most of work was done with nearly pure carbon shaped from electrode carbons such as used in arc lamps for projection. In addition, however, fuels of known ash content were investigated. Following conclusions were reached: (1) The specific surface-reaction rate for carbon spheres burned in dry and moist air is a complex function of particle size. It is enormously larger for a small particle than for a large one. (2) The temperature of the surface increases as the particle is reduced in size. (3) At lower velocities, below about 4 ft. per sec. as measured at 24 deg. C., reaction rate increases rapidly with increase in velocity, independent of other variables. This decreases continuously as the velocity increases until in high-velocity range a large increase in velocity increases reaction rate only slightly. (4) Size of particle, independent of other variables, has an effect on specific surface-reaction rate; that is, for the same air velocity and same surface temperature, a small particle has a higher specific surface-reaction rate than does a larger one. (5) Carbon spheres of surface area 70 to 10 sq. m.m. burn faster in dry air than in moist air. (6) The surface temperature is higher when the particles are burned in moist air. (7) An increase in surface temperature, for particles burned in dry air, increases the reaction rage—that is, the temperature coefficient is positive. Maximum temperature coefficient is associated with small particle size, high air velocity, and high surface temperature. (8) An

increase in surface temperature for particles burned in wet air at low velocities decreases the reaction rate, but for higher velocities the reaction rate increases with rise in surface temperature. (9) A mechanism explaining the observed effects of water vapor on the combustion of electrode-carbon spheres burned in wet air is suggested.—ROY N. YOUNG

Accurate air separator for fine powders. PAUL S. ROLLER. *Ind. Eng. Chem.*, Analytical Edition, April, 1931, V. 3, No. 2, p. 212-16.—Apparatus separates quantitatively a 1-kg. charge of fine powder into a series of fractions beginning 0-2.5 microns in size. Except for finest fractions, at or below 5 microns, where attrition by air current takes place in case of soft powders, particle sizes separated are very homogeneous within limits given by Stokes' law. Several causes affect rate of separation, but most important is that of rate of air flow. Under similar conditions rate of separation is proportional to air flow. Depending on the latter, initial rates of separation of particle-size fractions have been made up to 135 grams per hour at a flow of 140 liters per minute. Continuous separation can be effected by use of an offset separator tube with separate collection of oversize. At a 30-micron particle size cut of a portland cement powder, with an air flow of 500 liters per minute, equivalent rate of feed was 5.4 kg. per hour, while rate of recovery was 0.92 kg. per hour. —ROY N. YOUNG

Effect of mica and iron-mica on strength of mortar and concrete. G. KATHREIN. *Zement* (Germany), Feb. 19, 1931, V. 20, No. 8, p. 174-7.—Experiments at Institute for Mineralogy and Testing Materials at Technische Hochschule in Vienna (Austria) revealed interesting facts concerning effect of mica on concrete properties. Sand in 1:3 mortar specimens was replaced in certain proportions by mica. Compressive strength is lowered by 1 per cent mica; greater percentages cause rapid decreases in compressive strength. Tensile strength and weight per volume are increased by 2 to 5 per cent mica, decrease in strength takes place above 10 per cent. Similar tests were conducted with concrete specimens. Compressive strength is lowered with increasing W/C ratio and decreasing weight per volume. In general, mica has harmful effect on compressive strength and sometimes slightly improving effect on tensile strength. Experiments with iron-mica led to similar results.—A. E. BEITLICH

The rate of calcination of limestone. G. G. FURNAS. *Ind. Eng. Chem.*, May, 1931, V. 23, No. 5, p. 534-8.—Methods and apparatus used in the work are described. Curves are plotted showing relationship between rates of calcination and temperatures. Calcination of limestone takes place in a very narrow zone which is phase boundary between calcium carbonate and calcium oxide. Rate at which this zone advances from outside to inside of piece was constant for any given temperature used. Most of resistance to heat transfer into piece appears to be in narrow zone of calcination, and not in layer of calcined material. A method for determining surface area of particles from calcination data is suggested. The range of particle size used was 2.5 to 8.5 cm. —ROY N. YOUNG

Can by-product carbon dioxide be used in "dry ice" manufacture? D. H. KILLEFER. *Rock Products*, March 28, 1931, V. 34, No. 7, p. 71.—Gases with so low a concentration of CO_2 as those from cement and lime kilns cannot be profitably used at present for making dry ice. Gases from fermentation may be used at cost of removing odors, which is less than cost of removing other gases than CO_2 from usual combustion gases. Gas from coke burned under specially designed boiler has been used, the heat furnishing power to purify and compress about one-third of CO_2 produced.—EDMUND SHAW

PROPERTIES OF CONCRETE

Weather resistance of concrete brick. *Zement* (Germany), April 16, 1931, V. 20, No. 16, p. 375.—To show durability and weather resistance of concrete, a monument is illustrated which was built in 1867 and was awarded

a prize at world's fair in Paris. No visible defects can be detected on this 64 year old structure.—A. E. BEITLICH

The modulus of elasticity for concrete in compression. R. DUTRON. *Summary Reports First I. C. for C. and R. C.*—Modulus of elasticity for concrete is function of its strength, so by implication it depends upon all of factors which affect strength, richness in cement, nature and gauge of inert materials, fluidity, and age of concrete.—LA TECHNIQUE DES TRAVAUX

Study on slow deformations of cement. E. FREYSSINET. *Summary Reports First I. C. for C. and R. C.*—Study of the causes of error; provisional distinction between expansion and shrinkage; results of first series of experiments on rapid variations of shrinkage; variations of shrinkage during periods of long duration; influence of mechanical factors on shrinkage; thermo-hydrometric laws of shrinkage; hydro-elastic laws of shrinkage.—LA TECHNIQUE DES TRAVAUX

The design of the mix and pre-estimation of concrete.—The hardening of cements. L. VANDEPERRE. *Summary Reports First I. C. for C. and R. C.*—Inquiry as to mix of concrete with regard to materials available (cement, ballast or shingle, sand or dust) is based on previous determination of D (maximum diameter of the stones) and d (maximum diameter of the sand or dust). It has long been desired to transform curve of hardening of cements into a straight line by a logarithmic reflection of the values of the ages. In this hypothesis resistance of cement should be taken as increasing continually up to infinite age.—LA TECHNIQUE DES TRAVAUX

Study of the composition of concrete by means of modulus of fineness and of a water cement factor. ANT. BREBERA. *Summary Reports First I. C. for C. and R. C.*—The author considers "The provisional directions for the making of concrete," which he has arranged and which have been approved by the Ministry of Public Works of Czecho-Slovakia. According to these directions determination of best proportion of ballast and of sand is effected by a granulometric analysis on basis of ideal modulus of fineness, which he determines for materials of maximum determined size and by a mixture determined by diagram. Wetting of concrete corresponding to maximum resistance is deduced from author's original diagram.—LA TECHNIQUE DES TRAVAUX

Inert materials and the mechanical properties of concrete. R. DUTRON. *Summary Reports First I. C. for C. and R. C.*—Resistance of concrete to compression, tension, flexure and impact varies—apart from any ot er factor—with nature, shape and gradation of inert materials which constitute its skeleton. It may be stated that, in general, regarding inert materials dealt with in this paper, their order according to effect on compressive strength is almost the reverse of their order according to effect on the other resistances considered. —LA TECHNIQUE DES TRAVAUX

Sins of the concrete fellows. VAN DER KLOES. *Summary Reports First I. C. for C. and R. C.*—Inspection of a silo-building 10 to 12 yrs. old of armed concrete in a deplorable state of deterioration. The author attributes the bad condition to excess water in the concrete mixture, resulting in shrinking and bursting.—LA TECHNIQUE DES TRAVAUX

Mechanical theory of the setting and hardening of cement mortar and concrete. JEAN BASTA. *Summary Reports First I. C. for C. and R. C.*—In this theory, from the results of experimental tests with help of natural laws, are deduced rational equations for the resistance of concrete and also for their use in the calculations for constructions in concrete and reinforced concrete considered from both the static and dynamic points of view.—LA TECHNIQUE DES TRAVAUX

The use of concrete and ferro-concrete in the colonies. C. WOLTERBEEK. *Summary Reports First I. C. for C. and R. C.*—Suitability of concrete for construction in the colonies is discussed. Prevalence of good aggregates,

especially sand is of great importance. It is necessary to design watertight concrete without voids, especially in tropical countries, for great heat and blowing rain have the tendency to deteriorate the alkalinity of the concrete, and this results in a danger of rusting of embedded bars.—LA TECHNIQUE DES TRAVAUX

Light-weight concrete in practice. A. WEISS. *Zement* (Germany), Jan. 29, 1931, V. 20, No. 5, p. 101-5.—In an historical development of reinforced concrete skeleton construction method application of light-weight concrete for such structures is emphasized. Properties of this material are discussed and experiences with various kinds of light-weight concrete are described. Saving of space and high insulating properties are chief advantages.—A. E. BEITLICH

Concrete compressive strength and concrete age. RICHARD FAERBER. *Zement* (Germany), Feb. 19, 1931, V. 20, No. 8, p. 177-8.—A graphical method enables estimates of compressive strength of concrete at later ages. Two curves show relation between strength expressed in per cent of 28-day compressive strength and age in hours (in logarithmic scale) and days. Curves depend upon laboratory test results. Separate curves must be plotted for each individual cement. Method is of value in practice, especially for determination of strength of failed concrete and in cases where existing structures are enlarged or submitted to greater loads.—A. E. BEITLICH

Standard strength and concrete strength. WILHELM STOY. *Zement* (Germany), Feb. 26, 1931, V. 20, No. 9, p. 194-7.—Experiments were undertaken with 10 standard portland cements, 3 high quality portland cements and 3 natural cements to study relations between cement strength and concrete strength with specimens of varying consistency. Results of test support demands that in certain cases properties of cement should also be studied in mixtures of soft and wet consistency (representing better the conditions of practice) besides normal tests with earth-moist consistency. Sand of suitable grain composition should be used for these tests. It is also advisable to use a shaking table of smaller dimensions than asked for in standard specifications.—A. E. BEITLICH

Calculation of heat reactions in winter concreting. MAX MAYER. *Zement* (Germany), April 2, 1931, V. 20, No. 14, p. 322-5.—An empirical calculation method is derived which is based on 4 successive processes in mixing and placing operation of concrete. (1) Sand, gravel, cement and water of temperatures a, b, c and d are mixed and give a concrete of temperature e, (2) Concrete is transported to mold where it arrives with a temperature f, (3) is poured and cools off to temperature g. (4) After several hours concrete will have temperature h. Equations show final temperature of mixture of raw materials calculated from measured temperatures, heat capacities and radiation. Generation of heat in concrete due to chemical reactions of cement is important.—A. E. BEITLICH

About the elastic behavior of concrete with special consideration of diagonal tension. "Uber das elastische Verhalten von Beton mit besonderer Berucksichtigung der Querdehnung." HIROHIKO YOSHIDA. 1930, Julius Springer, Berlin (Germany), R. M. 11.00. Reviewed in *Zement* (Germany), March 12, 1931, V. 20, No. 11, p. 250.—Available information about determination of coefficient of transverse expansion of concrete is greatly enlarged by this book. After discussing previous work, different test methods are characterized such as compressive, tensile and bending test. Results show relations between stresses and elastic behavior of concrete under various loads. Effect of age, W/C ratio, normal compressive strength and cement content are described.—A. E. BEITLICH

New fundamental principles of concrete composition. "Neue Grundlagen der Betonzusammensetzung." OTTOKAR STERN, 1930, Editor: *Ostr. Ingenieur und Architekten Verein*, Vienna (Austria), R. M. 2.00. Reviewed in *Zement* (Germany), April 9, 1931, V. 20, No. 15, p. 352.—Preliminary work of a research program for numerous open questions of influence of aggregates

on quality and economy of concrete, discusses 2 important recent researches: Abrams' fineness modulus and Spindel's constructive concrete calculation. Complicated relations between concrete composition and concrete properties such as consistency, workability, density and strength properties are explained. Final conclusions are based on these theories and their importance for construction practice. Efforts are made to express numerically degree of workability and degree of consistency of concrete.—A. E. BEITLICH

Effect of heating on concrete materials in winter construction jobs. LUZ DAVID. *Zement* (Germany), March 5, 1931, V. 20, No. 10, p. 218-21.—Discussing work done by W. H. Bachelder (cf. *Eng. News-Rec.*, Dec. 18, 1930, p. 973) the author concludes: No objections exist against use of mixing water of temperatures of 140 to 176° F. when materials are mixed in right order. Strength of concrete at about 142° F. decreases only from 20 to 30 per cent. Favorable grain composition and use of high quality cements give in general strengths above specifications.—A. E. BEITLICH

Differentiation of the properties of cements. STIG GIERTZ-HEDSTROEM AND DONOVAN WERNER. *Zement* (Germany), March 5, 1931, V. 20, No. 10, p. 213-5.—After considering major properties of cements such as tensile and compressive strengths, solubility, shrinkage, heat development and setting, authors classify cement into 2 types: (1) Cement for hydraulic structures, which has decreased solubility and small heat development. This cement has probably greater shrinkage, smaller strength properties and slow hardening. (2) Cement for superstructures which hardens more rapidly and shows small shrinkage. It has higher strength, develops more heat and has a greater solubility.—A. E. BEITLICH

A method for the manufacture of concrete with especially high strength. WALTER MARSCHNER. *Zement* (Germany), April 2, 1931 V. 20, No. 14, p. 330.—In connection with a recent German application for patent (No. G 72951) Richard Grün uses as aggregates for manufacture of concrete entirely or partly broken portland cement clinker, high alumina cement clinker or an especially prepared burned material with a relatively high silica content. Compressive and tensile strength are greatly increased and durability in magnesium sulphate solution is considerably improved. Clinker reacts with cement only on its surface and its interior is not attacked even after long exposure to water. Tensile strength increases from 2 to 3 times under normal storage conditions and about 5 times in magnesium sulphate solution; compressive strength is about 3 times higher with addition of these materials than without them.—A. E. BEITLICH

Effect of limestone aggregates on strength of concrete and mortar. P. FILOSSOFOW AND A. SCHTEPETOW. *Zement* (Germany), Feb. 12, 1931, V. 20, No. 7, p. 152-5.—Compressive strength of various concrete mixtures made of high grade aggregates and limestone aggregates with different consistencies were examined. Strength of concrete varied with strength of coarse aggregates. Additions of aggregates of less strength affect strength of rich concrete more than of leaner mixtures. Strength of mortar, which corresponds to a concrete with strong aggregates, is less than strength of these concretes. Strength of mortar, corresponding to concretes with aggregates of less strength, is greater than strength of rich concrete (1:2:4) and less than that of lean mixtures (1:4:8). Poor aggregates affect mortar strength less than concrete strength. In lean mixes mortar strength and concrete strength are similar.—A. E. BEITLICH

Acoustic tests of materials of construction. *Genie Civil* (France), March 7, 1931, No. 10, p. 246-247.—In tests conducted at instigation of Touring Club of France at laboratory of Conservatory of Arts and Crafts, with M. Cellerier in charge, physical and mechanical properties of materials were investigated in their relation to transmission of sound. A distinction is made in acoustic tests bet veen sounds, of given frequency and amplitude, and noises, which are the complex effect of many simple sounds. Readings of the ammeter

of the measuring appratus were recorded for the sound produced: i upon passing through sample section; and I upon direct reception. The ratio of transmitted sound intensity to direct sound intensity was recorded for each material. Parallel tests were made of heat conductivity, permeability, combustibility, hygroscopicity, porosity and strength.—M. A. CORBIN

Modern proportioning of concrete. V. BAEHRNER. *Zement* (Germany), Jan. 22, 1931, V. 20, No. 4, p. 82-4.—Research work in laboratory of Cementa cement plant in Malmo (Sweden) yielded a new concrete proportioning system which takes into consideration quality of cement, consistency of concrete and gradation of aggregates. For calculation of mixture must be known: desired strength of concrete, quality of cement, maximum size of aggregates and desired consistency. With these data and aid of W/C table and proportioning table, can be easily determined proportions of cement, aggregates and water. Water-cement ratio table shows relation between W/C and concrete strength made of cements of different quality. Proportioning table shows relation between W/C, cement-aggregate ratio, amount of cement per unit of volume of concrete and consistency of concrete.—A. E. BEITLICH

How concrete in Wacker Drive attained great strength. *Concrete* April, 1931, V. 38, No. 4, p. 15-16.—Strength of 11,400 lb. was attained in Wacker Drive concrete, Chicago, due to complete hydration of cement particles. Process of hydration is best understood if fineness, or size distribution, of cement is considered, particularly with respect to quantity of fine sizes present. Length of time required for hydration is shortened as size of cement particles decreases. Ordinarily in building construction work, only three of fine sizes, representing about 45 per cent of quantity of cement, have time to become completely hydrated during short curing period and before remaining water is dried out. Three larger sizes, or 55 per cent of total quantity are never hydrated. In outdoor concrete, subsequent periods of rainy weather supply moisture that causes resumption of hydration of coarser particles and eventually all cement becomes hydrated and further strength is attained. Higher early strength is obtained with ordinary portland cement, partly by greater fineness and increasing percentage of smaller particles.—C. BACHMANN

Researches in concrete aid the engineer. H. F. GONNERMAN. *Civil Engineering*, May, 1931, V. 1, No. 8, p. 727-732.—Reinforced concrete construction was first proposed about 70 years ago by E. Coignet, a French engineer, and first investigations were made from 1870 to 1880 by an American engineer, Thaddeus Hyatt. From 1880 to 1900 important contributions to knowledge of subject were made by Feret, Considere, Monier, Hennelbique, Christophe, Bauschinger, Tetmajer, Bach, Martens, Morsch and others. During the period 1900 to 1914 American investigators, Talbot, Hatt, Humphrey, Turneaure and Withey reported numerous researches but properties of plain concrete were given relatively little attention. Agencies now engaged in study of concrete and related materials include national technical organizations, government bureaus, industrial organizations, and colleges. One interesting investigation consists of a study of the behavior of a variety of concrete structures over a wide range of climatic exposures and particularly those in direct contact with water. Observations indicate principal destructive agents are repeated freezing and thawing of saturated, porous concrete and solvent action of water finding its way through porous concrete mass.—D. E. LARSON

Some notes on proportioning concrete. HAROLD JAMES VOGAN. *Trans. Institution Engineers Australia*, V. 12, 1931, p. 1-15.—Concrete specifications of 1920 and 1929 are compared and revolutionary changes in design of mixes discussed, with comprehensive resume of theories for concrete design. The author points out the great value of fundamental work by Feret on mortar mixes in 1892. Fuller's mechanical analysis method, Abrams' water-cement ratio method and McMillan's recent work are reviewed. The value and significance of Power's and Edwards' contributions have not been overlooked. The results of work of Talbot and Richart in 1923, which contains investigations of funda-

mental importance, enables correct interpretation of results of other investigators. General comparison of methods and theories reveals agreement by investigators on fundamentals not apparent upon casual examination. These findings included: Importance of voids in concrete or mortar and percentage of cement; that strength and density of concrete are affected by variation in size of sand particles more than by variation in stone particles. None of the experimenters showed any advantage gained from sand with sharp grains. Tests bearing on these theories have been conducted at Peter Nicol Russell School of Engineering, University of Sydney. Comparison of actual and calculated values of W/C shows differences ranging from +1% to +12% and from -7% to -34%. More experiments are in progress.—N. H. ROY

Basic principles of concrete making. F. R. MCMILLAN. *Civil Engineering*, April, 1931, V. 1, No. 7, p. 601-606.—When aggregate in concrete is completely surrounded by cement-water paste, forming a uniform and homogeneous mass, properties of the concrete are principally determined by the properties of the hardened paste. In some cases, the properties of concrete are greatly affected by certain characteristics of the aggregate, but this does not reduce the importance of the paste for, regardless of kind or combination of aggregate, any change in properties of paste will at once be reflected in character of concrete. Chemical reactions responsible for setting and hardening which transform plastic cement-water paste into hard binding medium are termed hydrolysis and hydration. Curing conditions required for completion of these reactions are time, favorable temperature, and continued presence of water. Hydration is essentially complete at from 6 to 12 months both for standard portland cements and for high early strength cements. Strengths are correspondingly lower for shorter periods. Factors affecting these strengths are: relative proportions of cement and water, or w/c ratio; completeness of chemical combination between cement and water, that is, curing; characteristics of cement. These three factors also determine other qualities of the hardened paste such as watertightness and durability. In general, watertightness is a function of w/c ratio, time and rate of hardening just as compressive strength is a function of same factors. Principal disintegrating agencies are repeated freezing and thawing and action of percolating water.—D. E. LARSON.

Aggregates and the physical properties of concretes. (See MATERIALS —AGGREGATES.)

ENGINEERING DESIGN

BRIDGES

The bridge of Prince Joseph Poniatowski over the Vistula in Warsaw. B. PLEBINSKI. *Summary Reports First I. C. for C. and R. C.*—This bridge is known in Polish history of bridge construction not only as the largest bridge in Poland, 9840 ft. long (including the viaducts), but chiefly because for the first time concrete has been used on a large scale for its construction together with iron and steel.—LA TECHNIQUE DES TRAVAUX

Railway underbridges of concrete and reinforced concrete in Spain. J. EUGENE RIBERA. *Summary Reports First I. C. for C. and R. C.*—Note contains complete information on very large number of underbridges in concrete and reinforced concrete constructed in Spain in a period of over 20 years, with drawings of bridges of Torre Montalvo (concrete arches of 100 ft.) and straight bays at a sharp skew with a wide span of 65 ft. for the transpyrenean railway from Lerida to Saint-Girons.—LE TECHNIQUE TRAVAUX

Reinforced concrete in engineering. M. GERARD. *Summary Reports First I. C. for C. and R. C.*—Author deals briefly with some classes of engineering structures to which reinforced concrete has been applied in Great Britain. First among these are bridges, of which many hundreds have been built on the Hennebique system since the year 1900. Three improvements in jetty, pier

and quay construction introduced by Mouchel and his successors are dealt with in the succeeding section of report.—LA TECHNIQUE DES TRAVAUX

Test measurements on the Arlington Memorial bridge at Washington, D. C. J. FISHBURN. *Summary Reports First I. C. for C. and R. C.*—The Arlington Memorial Bridge Commission and the National Bureau of Standards of the United States Department of Commerce are jointly conducting a series of tests on the Arlington Memorial bridge, across the Potomac River at Washington, D. C. to obtain data on structural behavior of one of arch spans. The paper discusses principally design and construction of instruments used and accuracy of data obtained. Change in bending strain at points along the arch extrados, which occurred between adjacent tests is shown as computed from the test data.—LA TECHNIQUE DES TRAVAUX

The possibility of substitution of concrete arches over very large spans for metallic structures of all kinds. E. FREYSSINET. *Summary Reports First I. C. for C. and R. C.*—First part, study of possibilities arising from properties of materials. Second part, choice of forms of structures. Third part, methods of carrying out work.—LA TECHNIQUE DES TRAVAUX

Note on arched bridges in Switzerland. R. MAILLART. *Summary Reports First I. C. for C. and R. C.*—As regards Switzerland the picture is completed by several works of native conception absolutely free of foreign influence. Whilst greater part of these have been described, principally in *Schweizerische Bauzeitung*, and in the Reinforced Concrete Handbook of Emperger, a new process of arch construction has been described in detail as particulars have not previously been published.—LA TECHNIQUE DES TRAVAUX

Recent developments in arch design. W. L. SCOTT. *Concrete Constr. Eng.* (England), March, 1931, V. 26, No. 3, p. 180-187.—Increase in spans of reinforced concrete bridges during recent years has led to investigation of variable factors which, in past have been ignored or assumed to vary in a manner amenable to straightforward mathematical treatment. Assumptions for moderate span bridges, up to 150 ft., are not sufficient for spans of several hundred feet. Approximate assumptions have been made to standardize influence lines. Principal assumption consists in considering axis of arch to coincide with line of resistance from total dead load and to be a parabola of second degree. This is only true for uniform dead load and for large spans. Error due to this assumption cannot be disregarded especially for arches of the solid spandrel type. Another assumption is that variation in the moment of inertia due to diminishing depth of arch towards the crown varies according to value $I = I_c / \cos \alpha$, where I_c = cross sectional inertia at crown and α = angle of inclination of arch ribs with horizontal. These two assumptions are permissible for moderate spans. However total dead load is not uniform, variation being greater with solid spandrel than open spandrel type arch bridges. Hence instead of taking the curve of the arch axis to be a "square" parabola it is necessary to find curve that will coincide with line of pressure for loading, part of which is uniform and part variable. Further refinement of arch curve is to consider bridge loaded with one-half of average distributed superimposed loading and to make arch axis curve fit this condition. This curve will be a parabola of the fourth degree and may be expressed as follows: $\frac{y}{f} = 1 - (1 - k)\, m^2 - km^4$ where y = vertical ordinate of any section to mean fibre above springing level, f = rise of arch above springing level, m = horizontal distance of sections from the center line of the arch in terms of the half span, and k = a constant depending on the load variation. For economical variation in moment of inertia it is found by practice that suitable depth at springing is about 1½ times that at crown, corresponding moment of inertia is about 3½ times that at crown. With object of standardizing the investigation following expression for inertia variation is given: $I = I_c / \cos \alpha\ (1 - 0.7m^4)$. Maximum negative and positive moment at a section are obtained

from influence lines using ½ calculated superload as covering entire bridge. Secondary thrust is permanently eccentric producing shortening and hence flattening of arch. Arch shortening is produced also by shrinkage of concrete, displacement of abutments, and drop in temperature. Two devices are used to eliminate secondary effects: temporary hinges or hydraulic jacks to open arch at crown.—J. MARIN

The strengthening of metallic latt.ces by reinforced concrete. FR. EMIERGER. *Summary Reports First I. C. for C. and R. C.*—Strengthening of metallic lattices is so carried out that compressed bars are covered with bound concrete and tension bars are reinforced by additional bars welded at their ends to lattice framework. The method is explained with aid of example of a cantilever girder with a central span of 36.0 metres.—LA TECHNIQUE DES TRAVAUX

Fundamental data for the calculation of solid bridges. "Berechnungsgrundlagen fur massive Brucken." 1930, Wilhelm Ernst and Son, Berlin (Germany), R. M. 1.50. Reviewed in *Zement* (Germany), March 12, 1931, V. 20, No. 11, p. 250.—Book contains a list of all necessary data in concise form for design of solid bridges. Special consideration is given to German standard specification.—A. E. BEITLICH

Bridge piers in Suisan Bay supply test of concreting methods. C. R. HARDING. *Concrete*, April, 1931, V. 38, No. 4, p. 9-11.—Bridge of Southern Pacific Ry., has a total length of 5603 ft. and comprises numerous spans of steel construction, to support which, concrete substructures were built with bases resting upon solid rock. These abutments and piers were designed to carry their own weight, that of the substructure and certain specified engine and train loads, critical combinations were made of maximum live-load reactions, total dead load of superstructure and substructure with and without allowance for bouyancy, together with overturning effects of wind pressure, acting longitudinally, and transversely on spans and piers, horizontal tractive forces from stopping and starting trains, and horizontal forces against piers from wave action and pressure from stream currents. To prevent shattering of the concrete by earthquake tremors, the main piers were heavily reinforced. —N. H. ROY

Design of a bridge over Lake Maeler in Stockholm (Sweden). RICHARD FAERBER. *Zement* (Germany), Jan. 29, 1931, V. 20, No. 5, p. 105-9.—Bridge design by Faerber and Schuhmacher, submitted to international contest (cf. *Zement* (Germany), July 1930, V. 19, No. 30, p. 712-4; *Journal A. C. I.*, Oct., 1930, V. 2, No. 2, *Abstr.* p. 39) embodies unique features. Use of rammed concrete is proposed. Design of 2 dissimilar arches was necessary on account of location of suitable sound rock for foundation of river pier. Spans of arches are 738.2 and 524.9 ft. and their heights are 74.1 and 66.9 ft. These are record dimensions for this type of bridge. Arches are 7.2 ft. thick at center and 12.1 ft. at abutments. Total width of bridge is 80.7 ft. Greatest stability and durability and smallest costs of upkeep were demanded. Arches are designed in 3 parallel strips to reduce costs of centerings. Detail are given of calculation of stresses and deformations of structure. Mixing devices are provided with automatic measuring equipment for water. Concrete is to be rammed by means of compressed air to increase strength and uniformity. Roadway consists of a number of similar slab sections, which rest on 4 horizontal beams, supported by 2 transverse beams.—A. E. BEITLICH

Method of arch design. G. P. MANNING. *Concrete Construction Eng.* (England), April, 1931, V. 26, No. 4, p. 250-53.—By using "ready made" influence lines labor of preliminary arch designs and estimates is reduced and errors eliminated. If abutments are expensive, open-spandrel arch is selected; if head room is insufficient ribs may be carried up through deck. For open-spandrels, spacing of ribs is next decided and deck designed. Two profiles are selected as being generally useful as first assumption. Influence lines are

obtained from tables given also maximum moments, thrusts, and shears for all sections of arch rib. Best shape of arch is determined from loads and working stresses for each particular case.—JOSEPH MARIN

A concrete arch of 460-ft. span. G. S. RICHARDSON. *Eng. News Record*, Apr. 23, 1931, V. 106, No. 17, p. 680-683.—The largest concrete bridge project yet planned by Allegheny County involves 1,500 ft. of high-level structure over Turtle Creek Valley and includes five reinforced concrete arches, one of which is 460 ft. long between pier centers. All piers and abutments are founded on solid rock. Each span has two arch ribs 14 ft. wide. Deep ribs were avoided on account of temperature and rib shortening stresses. All ribs are designed for maximum working stress of 800 lb. per sq. in. under combined dead load, live and impact load, rib-shortening and temperature stresses, this working stress being based on minimum 2000-lb. concrete. Temperature stresses are calculated for drop of 40 deg. and rise of 20 deg. F. Columns on the ribs are arranged in pairs so that, in cross-section, each bent forms a four-legged rigid frame with adequate lateral stiffness to tie two ribs together. Expansion joints are provided at the ends of span only.—D. E. LARSON

The contest for the Dreirosen bridge in Basel (Switzerland). *Zement* (Germany), March 26, 1931, V. 20, No. 13, p. 298-302.—In addition to description of bridges given by Berger (cf. *Zement* (Germany), Jan. 15, 1931, V. 20 No. 3, p. 59-61; *Journal A. C. I.*, April 1931, V. 2, No. 8, *Abstracts*, p. 223), two designs, awarded prices, are illustrated. (1) Continuous reinforced concrete beam with one fixed end at shore abutment and movable bearings at other supports. Bridge has 4 openings and rests on 2 river piers and 1 shore pier. Caisson method is proposed for placing of river piers. Calculation of stresses is given as well as exact data concerning excavating, proportioning of concrete and arrangement of mixing plant and transportation of concrete at site of construction. (2) Three-hinged reinforced concrete frame structure has 3 openings, 161.4, 331.4 and 161.4 ft. wide. Cross-section of 3 hollow beams which support roadway have interesting design. Roadway consists of cross-reinforced slab 8 in. thick. River pier foundations are caissons.—A. E. BEITLICH

The Echelsbach bridge. A Melan-arch with longest span. "Die Echelsbacher Brucke. Der weitestgespannte Melanbogen." F. DULL AND R. GERHART, 1931, Wilhelm Ernst und Sohn, Berlin (Germany), 76 p., 88 illustrations, R. M. 8.40. Reviewed in *Bautechnik* (Germany), March 20, 1931, V. 9, No. 13, p. 191.—A very complete picture of outstanding reinforced concrete arch bridge, great span of which was built without any centerings, is presented and various designs are discussed. Every phase of construction program is described in all details. Arrangement of site of construction, concrete mixing plant and transportation of structural materials are illustrated. Static calculations are given in full.—A. E. BEITLICH

Laboratory tests of reinforced concrete arches with decks. WILBUR M. WILSON. *U. of I. Eng. Exp. Sta. Bulletin* No. 226. April, 1931.—Eight reinforced concrete arches of 17 ft. 6 in. span and 4 ft. rise were tested to destruction. Two specimens were composed of ribs only. Two had rectangular deck slab supported on columns well above crown of arch, and had no expansion joints. Two had T-shaped deck slab supported on columns well above crown, one of these having expansion joints at third points. Two had T-shaped deck slab placed low and built monolithic with rib at crown, one of these having expansion joints at third points. All specimens were subjected to same distribution and intensity of loading (to failure) with greater intensity on one side of the center than on the other. Strains were measured on both concrete and reinforcing. Celluloid models of the experimental arches, and of other arches having various geometrical properties, were tested. Conclusions from this investigation are: Deck and arch rib act together structurally and analysis should be made on this basis for any important structure; expansion joints reduce the strengtening effect of the deck; when the deck is placed high above the rib at center (generally an unwarranted arrangement) expansion

joints may be necessary in medium and long spans; when vertical clearance is large it will generally be advantageous to increase rise of rib and place deck low with respect to rib.—ARTHUR R. LORD

Concrete trusses and 47-ft. slabs in new Seattle viaduct. CLARK H. ELDRIDGE, *Eng. News Record*, April 16, 1931, V. 106, No. 16, p. 642-644. Distinguishing features of reinforced-concrete design, of West Garfield St. bridge, recently completed in Seattle include heavy flat slab construction on spans up to 47 ft. and reinforced concrete trusses 60 ft. long. The structure is 3,010 ft. long between abutments. Design specifications were based on a live load of two 20-ton trucks with 100 per cent impact allowance on rear axle of one truck. A concrete mix of approximately 1:2:3, developing 3000 lb. per sq. in. in 28 days, was specified, and a working stress of 1,200 lb. per sq. in. used in design. The one-way slab section of bridge consists of bents of two or more columns capped with wide shallow beams. A heavy slab, reinforced primarily in one direction and thickened for negative moment at supports, spans directly from bent to bent, without beams or girders. Advantages of this type of construction include: simple formwork; large and uncrowded reinforcing bars; use of concrete of low water content; thorough curing; maximum clearance; distribution of heavy wheel loads; low cost. Reinforced concrete trusses have 60-ft. spans with 15-ft. cantilever panels at both ends. A 13-ft. suspended slab spans between cantilever ends of adjacent trusses. Lower chords and tension diagonals of truss consist of flat structural-steel bars connecting with ends of compression members by curved plates that loop around and engage concrete. These flat bars are wrapped with wire mesh and concrete is poured around the assembly.—D. E. LARSON

BUILDINGS

Applications of reinforced concrete in building construction. A. LOPEZ-FRANCO. *Summary Reports First I. C. for C. and R. C.*—A summary of the works of this kind planned or carried out by authors since 1910 in which they began to practice in this speciality, omitting details of procedure and design.—LA TECHNIQUE DES TRAVAUX

Roof of thin reinforced concrete slabs.—System Zeiss-Dywidag. FR. DISCHINGER. *Summary Reports First I. C. for C. and R. C.*—Author gives complete description of development of roof of thin reinforced concrete slabs of Zeiss-Dywidag system, which are known by monumental structures of covered halls of Frankfort and Leipzig. He examines the possibilities of further developments.—LA TECHNIQUE DES TRAVAUX

Spacious reinforced concrete hangar for the Seville airport. A. PENA BOEUF. *Summary Reports First I. C. for C. and R. C.*—This hangar is destined to hold two Zeppelin type airships. It is designed to be built of reinforced concrete, forming a series of parabolic arches, the centre of gravity of which lies on the directrix of main arch which is in shape of a normal catenary. It is calculated for the fundamental effects: dead weight, force of wind and thermic effect, and two hypotheses have been taken, corresponding to the thrust of the outer air and the simultaneous thrust of interior.—LA TECHNIQUE TRAVAUX

State hospital for children in Bern (Switzerland). F. HILLER. *Schweizerische Bauzeitung* (Switzerland), Jan. 3, 1931, V. 97, No. 1, p. 3-6.—Modern hospital was erected in reinforced concrete skeleton type. All floors, except cantilevered rest room floors, were built as supportless hollow brick structures. Floors of rest rooms were made of solid reinforced concrete. Visible expansion joints allow for shrinkage of concrete.—A. E. BEITLICH

Concrete mill design governed by machinery layout. EDMUND WILKES, JR., *Eng. News Record*, Apr. 2, 1931, V. 106, No. 14, p. 561-564.—Plant of the Ralston-Purina Co., at Denver, Colo., offers an interesting example how predetermined machinery layouts may affect reinforced concrete design.

Three main units of plant incorporated in a single structure are (1) a grain elevator headhouse 56 x 76 ft. in plan and 112 ft. high, surmounted by a cupola 74 ft. high; (2) a battery of fifteen grain tanks 18 ft. in diameter and 89 ft. high; (3) a feed mill 52 x 180 ft. in plan and eight stories high. Feed mill building contains five groups of rectangular bins nearly all of which are two stories deep. Bin locations were fixed by machinery layout and could not be shifted to accommodate structural design. Room for beams underneath bin walls was not available so the walls were made self supporting and concrete floors were suspended from them. Columns, beams and walls in bin area were constructed of reinforced concrete poured in continuous vertical run using sliding forms. Pockets were left in columns and walls to support floors, which were designed as two-way slabs supported by beams in both directions with exception of those supported from walls.—D. E. LARSON

Results of measurements of deformations and stresses of mushroom slabs. M. ROS AND A. EICHINGER, *First I. C. for C. and R. C.*, Liege, Sept., 1930.—Tests were made on six different mushroom slabs having square panels. Results of measurements of stresses, for Poisson's ratio $m = \infty$ and $m = 6$, and deflections are summarized for two buildings as follows: (1) Maximum moments in middle of panel, or half way between two columns are not essentially different from one another for loads uniformly distributed in a series of panels in line. (2) Points of inflection of elastic curve, for plane passing through axis of columns, i. e., the points where moment is zero, are from $0.22L$ to $0.28L$ distant from the axis of columns. (3) Bending moment of columns below and above slab (M_o and M_u), the latter having load uniformly distributed in a series of panels in line, permit: $M = M_o + M_u = \frac{pl^3}{16.8}$. M should be distributed on the two columns. For unusually strong columns and for considerably developed mushrooms, bending moment which obtains at two columns, reaches a value perceptibly higher, and may even exceed the value, corresponding to entirely built-in or fixed condition, $M = \frac{pl^3}{12}$. Maillart in 1908 found the following: for uniform load in panel of mushroom slab considered, calculated according to surface of deflection, in middle of panel, $M = \frac{Pl^2}{37}$, halfway between two columns, $M = \frac{Pl^2}{22}$. On two different mushroom slabs with ratio of length to breadth 1.8:10, results summarized are: (1) Bending moments in middle of panel and half way between two columns are equal for a load uniformly distributed in a series of panels in line (with longer sides adjacent) (2) Calculation by method of substitute or auxiliary frame gives values in close agreement with values obtained by measurements, for: positive moments in middle of a panel and halfway between two columns; negative moments at built-in or fixed point; bending moments of columns; and for deflections.—R. B. B. MOORMAN

DAMS

Hydro-electric plant at Porjus, Sweden. GEORGE WILLOCK. *Canadian Engineer*, Jan. 27, 1931, V. 60, No. 4, p. 9.—Hydro electric power plant, run and owned by Royal Board of Water Falls, Sweden, most northerly power plant in the world, has dam 4100 ft. long consisting of three parts, one portion forming the intake. To reduce ice pressure upstream faces are given a gradual slope with piers, walls, crest and downstream sides of spillways protected by a stone coating anchored to concrete foundations. The intake structure is of solid concrete.—G. M. WILLIAMS

Honeycomb gravity-type concrete dams. C. E. GRUNSKY. *Civil Engineering*, April, 1930, V. 1, No. 7, p. 630-631.—A new type of concrete gravity dam having galleries for cooling and draining the interior is suggested

by author. There is tendency for temperature in interior of massive concrete structures to rise for some time after concrete has been placed. To simplify the high gravity dam, it should be straight, not arched; to take advantage of water pressure, treated as load, its upstream face should be inclined; to prevent cracking there should be both horizontal and vertical joints, not too far apart; to keep water from permeating concrete and reaching joints and cracks where its presence under pressure would be undesirable, masonry near upstream face should be thoroughly drained, or a metal diaphragm should be provided. Any part of dam above an assumed horizontal plane at any elevation should be planned to satisfy the requirements of a dam with its base at level of assumed plane. The new dam suggested by author has an inclined upstream face with an imbedded metal membrane to prevent penetration of water. Fair-sized galleries, open at the downstream face, are provided both to cool the interior and reduce the weight of masonry. Vertical joints are carried from top of dam to foundation.—D. E. LARSON.

MISCELLANEOUS

The largest reinforced concrete syphons in the world. J. EUGENE RIBERA. *Summary Reports First I. C. for C. and R. C.*—Siphon of Sosa is formed of two tubes 3350 ft. long and 12.5 ft. in diameter; that of Albelda of a tube 2360 ft. long and 13.1 ft. in diameter. Both constant head of 85 and 98.5 ft. and for more than 20 years are of normal service to irrigate 247,000 acres in Aragon and Catalonia.—LA TECHNIQUE DES TRAVAUX

Reinforced concrete construction in Poland. W. PASZKOWSKI. *Summary Reports First I. C. for C. and R. C.*—Conditions in Poland have favored use and development of reinforced concrete from its introduction, the country being rich in raw materials required for making portland cement and in all kinds of stony materials suitable for concrete.—LA TECHNIQUE TRAVAUX

Progress of reinforced concrete construction in Germany. W. PETRY. *Summary Reports First I. C. for C. and R. C.*—The basis of the constructive design and carrying out of works in reinforced concrete is governed by official regulations, at the moment in process of revision. Working loads depend on execution and the supervision. The conditions of a good execution will be assured and increased by the directions of control of German Association of Reinforced Concrete.—LA TECHNIQUE DES TRAVAUX

Tests on the hooked ends of reinforcing bars. TH. WYSS. *Summary Reports First I. C. for C. and R. C.*—Question of maximum curvature permissible for anchorage hooks is discussed on basis of recent experiments on forming of steel reinforcement.—LA TECHNIQUE DES TRAVAUX

Railway sleepers in reinforced concrete. FR. EMPERGER. *Summary Reports First I. C. for C. and R. C.*—Two slabs (blocks) and a junction piece are assembled in position for a single sleeper. Slabs are of a form appropriate to their use and suitable for bearing on ballast. A complete comparison is made with usual systems of reinforced concrete sleepers in use on the Hungarian and French railways.—LA TECHNIQUE DES TRAVAUX

Theorical and experimental study of the load capacity of concrete piles.—Concrete piles with enlarged base. J. SPRENGER. *Summary Reports First I. C. for C. and R. C.*—The "reinforced concrete pile with enlarged base," an invention of the author, proved to have larger resistance at base than an ordinary concrete pile. For this reason an increase of 50 per cent to the allowable load seems to be correct. A formula for reinforced concrete piles is deducted.—LA TECHNIQUE DES TRAVAUX

The crippling of rectilinear members of eccentric loads. M. R. CHAMBAUD. *Summary Reports First I. C. for C. and R. C.*—The analysis of Euler which determines exactly the critical crippling load for axial loading cannot be extended to crippling by eccentric loading, and attempts made in this direction have tended to some extent to falsify ideas on the true nature of

the phenomenon. Present memoire presents an exact theory of eccentric crippling based on complete equations of bending and properties of elliptic functions.—LA TECHNIQUE DES TRAVAUX

Calculation of columns of reinforced concrete with spiral reinforcement. J. PODOLSKY. *Summary Reports First I. C. for C. and R. C.*—In the calculation for buckling of reinforced concrete columns with spiral reinforcement, limit of the resistance of the concrete is determined by formula of M. Navier. We can find by two methods the radius of inertia (radius of gyration) of section of columns reduced to the form of concrete. We can determine this radius of inertia. The two methods give satisfactory results.—LA TECHNIQUE DES TRAVAUX

Experimental research with influence lines relative to plane rigid constructions. G. MAGNEL. *Summary Reports First I. C. for C. and R. C.*—Structures in reinforced concrete present numerous problems in the solution of rigid systems. The most perfect systems of calculations are based on a series of simplifying hypothesis. Author's microinfluentiometer permits formation on celluloid models of influence lines of rigid elements with a maximum error of 2 per cent.—LA TECHNIQUE DES TRAVAUX

Calculation of combined bending, (bending and tension) by the aid of a new rule adapted from the logarithmic system of Rieger for the calculation of combined bending (bending and compression) by the aid of 3rd rule adapted to the rule of Rieger. J. RIEGER. *Summary Reports First I. C. for C. and R. C.*—The author has found it necessary to complete his rule by a fourth rule for the calculation of eccentric tension. The disposition of this rule is analogous to that of the 3rd rule.—LA TECHNIQUE DES TRAVAUX

Report on plane bending. JOHN SOUBRE. *Summary Reports First I. C. for C. and R. C.*—Author has deliberately confined his work to case in which section is subjected to compression throughout its extent. Taking as a point of reference the neutral axis and not centre of gravity of imaginary section, he states the various equations of equilibrium and derives from them a series of formulae which constitute an easy method of calculation applicable to various problems met with in current practice.—LA TECHNIQUE DES TRAVAUX

The mean fibre of large rigid arches. F. CAMPUS. *Summary Reports First I. C. for C. and R. C.*—By reason of permanent, elastic and reversible shortenings of large rigid arches, the funicular polygon of fixed loads does not constitute most favorable forms of mean fibre of these structures. A direct simple method of correction is deduced from the ingenious conception of Prof. E. Timochenko, which consists of calculating hyperstatic arches, of which the mean fibre coincides with the funicular polygon of the loads or is very near to it, by taking as a basic isostatic system the three hinged arches.—LA TECHNIQUE DES TRAVAUX

Experiments of the form of lines of principal stress in problems of two dimensions. AUGUSTE MESNAGER. *Summary Reports First I. C. for C. and R. C.*—It is known that in two dimensions lines of principal stress form two families of orthogonal curves which are perpendicular or tangent to contours, and that resultant angles form single points of first order and salient angles of second. By superimposing the two solutions we obtain forms relative to problems of St. Venant for girders loaded at one point.—LA TECHNIQUE DES TRAVAUX

Calculation of relatively thin annular sections uniformly reinforced on their circumference and stressed by plane bending and direct load. LOUIS BAES, LUCIEN VANDEPERRE AND JACQUES VERDEYEN. *Summary Reports First I. C. for C. and R. C.*—The problem of annular sections of this type is chiefly met in pylons or posts and chimneys in reinforced concrete. The authors have made the graphs which form the subject of the note in connection

with an expert investigation for a chimney of reinforced concrete.—LA TECHNIQUE DES TRAVAUX

Calculation of straight members of rectangular section doubly reinforced and stressed by plane bending and direct load. LOUIS BAES AND LUCIEN VANDEPERRE. *Summary Reports First I. C. for C. and R. C.*—The note presents two types of solutions by graphs. The first consists of a series of five graphs of which one only is given.—LA TECHNIQUE DES TRAVAUX

Examples of the construction statics. "Ubungsaufgaben aus der Baustatik." RICHARD LINDT, 1930, Max Jänecke, Leipzig (Germany), Part 1 and 2, RM. 3.00. Reviewed in *Bautechnik* (Germany), March 20, 1931, V. 9, No. 13, p. 195.—More than 540 examples from all fields of statics are given. They deal with composition and separation of forces, determination of loads and stresses in structural members, calculation of beams and columns, strength, wind pressure, water pressure and earth pressure. Laws of statics are illustrated.—A. E. BEITLICH

Symmetrically reinforced sections under eccentric loads. A. PUCHER. *Beton u. Eisen* (Germany), April 20, 1931, V. 30, Heft 8, p. 156-158.—In consideration of concrete stresses in extreme fibres of rectangular and ring sections eccentrically loaded, concrete symbols are substituted into formula for stress due to axial load combined with bending and an expression is obtained for the ratio of max. and the min, f_c to the average f_c in terms of properties of section, eccentricity, constant n (15 is used), and steel ratio. This expression is for construction of charts giving for various eccentricities and steel ratios the ratio of max. and min. f_c to average f_c. Chart for rectangular sections covers a range of (total) p values up to 6 per cent and eccentricities up to 0.35. Chart for ring sections includes sections varying from thin shelled cylinders (shell thickness equal to 0.025 of outside diameter) to solid sections. Charts are constructed on assumption that concrete takes tension and that n equals 15.—A. A. BRIELMAIER

Economic design of reinforced concrete piles. J. P. PORTER. *Concrete Constr. Eng.* (England), March, 1931, V. 26, No. 3, p. 202-210.—Greater economy in design of concrete piles is permitted because of development in strength of cement, introduction of rapid-hardening cement, greater care taken in making concrete and information on bearing values of piles. Factor of safety is determined based upon: quality of material passed through, ratio between bearing and frictional support, ratio between dead and live load and possibility of frictional support being increased by re-settlement of the ground. Second step is to determine dimensions and arrangement of the piles to be used. Considerations in designing a series of piles are: quality of concrete, stresses to be used, bending moments during handling, safe short-column length of pile and probable ground resistance. Allowable stress of 18,000 lb. per sq. in. in steel is proposed. Table given of allowable compressive strengths of concrete of different grades for a factor of safety of 3 and value of modulus ratio m = 15, 12, 10, and 8 for the different grades of concrete considered. Allowable stresses in shear for concrete is based on assumption of Navier's theory of failure. Attempt is made to treat subject of lateral reinforcement theoretically rather than empirically.—J. MARIN

The economic design of reinforced concrete piles. J. P. PORTER. *Concrete Constr. Eng.* (England), April, 1931, V. 26, No. 4, p. 236-44.—Loads and forces sustained by piles are: (1) bending and shear stresses while being handled, (2) compression, shear, and possibly buckling crushing stresses while being driven—in body of pile, (3) crushing stresses while being driven—in head and foot of pile, and (4) compression, shear and possibly buckling stresses under working load. Reinforcement of 2 and 4 per cent is selected. Expressions are given for maximum moments produced for specified types of slings, and for maximum length of piles in terms of resisting moment and cross section. Approximate relation is obtained for resisting moment in terms of

cross-sectional dimensions of pile, area of steel, distance of steel from edge and distance of neutral axis from outer fibre. Shear strength for long piles is supplied by links. Relation is deduced for shear assuming pile supported at one end and at quarter point. Shear steel is necessary to resist impact stresses, to give resilience, to resist bursting pressure of concrete and to prevent buckling. Quantity of shear steel should be at least doubled for the first 2 or 3 ft. at head and foot of pile. Pile is assumed as "short column" if hammer blow is axial and if equivalent "unsupported" length does not exceed 15 times core width. In selection of piles, number and spacing to be used is determined and working load per pile derived. Ultimate ground resistance to which pile is to be driven is determined. If "short column action" only is the condition, a suitable pile can be selected from table. If "long column action" is likely, ultimate ground resistance is multiplied by a reduction factor to determine the safe "short column" load.—JOSEPH MARIN

Modern reinforced concrete structures of special designs. WILHELM PETRY. *Zement* (Germany), Feb. 12, 1931, V. 20, No. 7-8, p. 149-52, 170-4.—Recently completed reinforced concrete structures of special interest on account of peculiarities in their design and construction include: Retaining wall at sand beach in Wannsee (Germany); reinforced concrete tunnel for bituminous coal mine in Finkenheerd which was constructed over railroad of mine, under considerable difficulties; foundation of a traveling coal unloading crane on Teltow channel; Several loading platforms for sand, lime-stone for new cement plant in Neuwied (Germany), coal and aggregates.—A. E. BEITLICH

The rational reinforcement of concrete. *Engineering* (England), March 27, 1931, V. 131, No. 3402, p. 409.—Distribution and arrangement of steel in secondary reinforcement to resist shearing stresses should provide for its disposal along tension lines of principal stress. Use of stirrups perpendicular to neutral axis of beam is uneconomical since principal stresses cut neutral axis at angle of 45 deg. Main reinforcing bars not needed for tension should never terminate parallel with the upper surface of beam but should first be turned at an angle of 45 deg. to neutral axis, and then bent round further so as to end at right angles to upper surface. Any shear can be resolved into a tension and a compression at right angles to each other. From symmetry best arrangement of metal to take tensions will be to place it at right angles with line of thrust. Hence in reinforced concrete truss steel work should be arranged horizontally in tension members and at right angles to axis of struts. In case of bow string girders these members are subject to bending moment as well as direct thrust or pulls and reinforcement should be given a corresponding curvature, meeting compression face perpendicularly but tension side at angle of 45 deg.—G. M. WILLIAMS

Report of the 33rd main meeting of the German Concrete Association on March 17, 18 and 19, 1930. "Bericht uber die 33ste Hauptversammlung des deutschen Beton-Vereins am 17., 18. und 19. Marz 1930." 510 pages with numerous illustrations and tables. Reviewed in *Bautechnik* (Germany), March 20, 1931, V. 9, No. 13, p. 193.—Book contains complete text of 15 papers presented at this meeting and gives a review of newest developments in reinforced concrete practice and its many applications. Descriptions of outstanding structures, mostly erected in Germany, and theoretical discussions are included.—A. E. BEITLICH

Load members. "Belastungsglieder. "A. KLEINLOGEL, 1931, Wilhelm Ernst und Sohn, Berlin (Germany), 4th edition, 117 pp., 127 illustrations, 32 tables, RM. 9.00. Reviewed in *Bautechnik* (Germany), March 20, 1931, V. 9, No. 13, p. 192.—This is a supplement to several books by same author. Besides load members it discusses all static values, moments and transverse stresses. Formulas and equations are presented in simple and clear manner. Main chapter deals with stresses and moments of simple beam for single loads, square, triangle and trapezoid-loads.—A. E. BEITLICH

Stirrups in concrete beams located with charts. T. GERMUNDSSON. *Concrete*, May, 1931, V. 38, No. 5, p. 41-42.—A large chart has been constructed, based upon usual method of determining spacing of stirrups and composed of a series of vertical lines for each size of bar commonly used. It is necessary to calculate total shear to be carried by stirrups at two points, at support and at center of span. A line connecting these two points on the chart enables designer to read directly number of stirrups required and their spacing. —N. H. ROY

Short-cuts in structural design. JAMES R. GRIFFITH. *Concrete*, April, 1931, V. 38, No. 4, p. 36-38.—Chart II gives intensity of pressure under footings. Chart resembles a contour map of a hill. It may be used in computing soil pressures under foundation walls of buildings, chimney footings, bridge piers and similar cases. To use the chart, overturning moments must be calculated. These moments are taken about base and parallel to either side of structure. Maximum pressure under footing is a constant, K_r, times the unit load on the base. The value K_r is read from the chart, using the overturning moment, the total load on the base and one dimension of the base.—N. H. ROY

Application of influence lines to the design of rigid frames. W. CHERRE. *Concrete Construction Eng.* (England) April, 1931, V. 26, No. 4, p. 252-64.—Method of constructing influence lines for moments and shears in rigid frames, is based upon assumed variation in moment of inertia expressed by an equation giving moment of inertia at any section in terms of that at center of span, length of span, ratios of inertias at center and at supports, and a coefficient. Expressions are derived for moments at ends of spans in terms of rotations at ends. Equations defining positions of fixed points are determined, from which rotations of girders and columns of frames are obtained. From values of rotations, bending moments due to unit loads for different sections are found and plotted. From these curves influence lines are drawn. Method of constructing influence lines for shear is outlined.—JOSEPH MARIN

Nomogram for calculating the allowable distance between vertical or inclined stirrups of beams and slabs as determined by diagonal tension and shear. JORGE QUIJANO. *Ingenieria* (Mexico), June, 1930, V. 4, No. 6, p. 253-254. A nomographic chart for use in designing or investigating the distances between vertical or inclined stirrups, which solves the relation $T = S\,(v—2.8)b$.—(Author's correction to 5th abstract, A. C. I JOURNAL, Jan. 1931; *Abstracts* V. 2, p. 146).

ROADS AND PAVEMENTS

Where more research is needed in concrete highway work. *Concrete* April, 1931, V. 38, No. 4, pp. 33-34.—Replies to inquiry among engineering officials of state highway departments indicate more information is needed on a number of problems, in approximately following order of importance: (1) Studies of subgrade soils, drainage and frost action, and their relation to concrete pavements. (2) Design of concrete mixtures, with special reference to simplicity of procedure. (3) Factors affecting durability of concrete. (4) Design of pavement slabs and sections, and studies of slab action. (5) Comparative efficiency of improved methods of curing. (6) Traffic surveys. (7) Concrete materials for highway pavements. (8) Use of coarser sizes of aggregates in concrete mixtures. (9) Construction methods. (10) Causes and prevention of cracking. (11) Studies of cement.—C. BACHMANN

Cement joints in concrete roads. C. H. CONNER. *Canadian Engineer*, March 31, 1931, V. 60, No. 13, p. 24.—Inspections show that concrete pavements with properly placed steel reinforcement, divided longitudinally and transversely by joints give far better service than plain concrete without joints. Generally all pavements 18 ft. or wider are divided by longitudinal joints. Some are cut through pavement and joint filled with filler while others may be hidden or partially cut through. Spacing of transverse joints usually varies between 30 and 50 ft. Present tendency is toward use of wide expansion joints

spaced at rather wide intervals with one or two contraction joints between them, such as ¾ in. expansion joint at 80-ft. intervals with one dummy contraction joint at 40 ft. intervals for a 40-ft. spacing. Generally a 1-in expansion interval for each 100 ft. of slab is recommended.—G. M. WILLIAMS

ARCHITECTURAL DESIGN

The new telegraph construction office building in Stuttgart (Germany). *Zement* (Germany), March 12, 1931, V. 20, No. 11, p. 247.—Large structure was built entirely of reinforced concrete. Building, 460 ft. long, is especially distinguished by precision in construction of exterior and interior. Architectural design is discussed.—A. E. BEITLICH

The architecture of reinforced concrete in Holland. J. DUIKER AND G. MEYERS. *Summary Reports First I. C. for C. and R. C.*—In Holland, as in other countries, reinforced concrete architecture has no existence as a characteristic national architecture. The architecture which is characteristic of reinforced concrete derives from the skeletal form of construction adopted; outside walls carry no load but serve only to separate the interior from the exterior. Such a way of building can allow a front wall almost entirely of glass. Style is determined by the principle which underlies construction; thus it may be noted how Classical and Gothic construction gradually acquired greater lightness and delicacy. It is in this way that reinforced concrete may lead to the development of a new style.—LA TECHNIQUE DES TRAVAUX

Decorative concrete. JOHN J. EARLEY. *Concrete Products*, April, 1931. V. 40, No. 4, p. 50-52.—In review of work done by the writer in developing use of color in concrete by means of colored aggregates, he states that recently a doubt has arisen not as to superiority of exposed aggregate method but as to universality of its application. Its use is likely to be restricted, leaving need for another treatment of concrete for more general use. This will perhaps take the form of a surface treatment though one that will be more nearly an integral part of the concrete itself than anything so far developed.—E. S. HANSON

The new reinforced concrete bridge with artificial granite surface over the Escaut at Eyne, Belgium. E. TASHJIAN. *Genie Civil*, (France) April 11, 1931, No. 15, p. 376-377.—Bridge built by State of Ohio in commemoration of the passing of the 37th Division of the American Army in October 1918, replaces structure torn down in 1914 by retreating allied armies. Its graceful lines, decorative sculptures and artificial granite surface are much admired. It was designed by Walker & Weeks, Architects, Cleveland, Ohio and erected by Messrs. De Cavel, Chief Engineer, Heylbroeck and De Nayer, Assistant Engineers of Roads and Bridges, Belgium. Artificial granite forms an integral part of structure, being poured into a space next to form, separated from the interior by a wire mesh, keeping in place special aggregate consisting of 40 per cent quartz, 40 per cent white Carrara marble, 20 per cent black Carrara marble. White cement was used.—M. A. CORBIN

FIELD CONSTRUCTION

BRIDGES

Arch bridges. "Bogenbruecken." C. KERSTEN, 1930, Wilhelm Ernst and Son, Berlin (Germany), second volume of: Reinforced concrete bridges "Bruecken aus Eisenbeton," 5th revised edition. R. M. 16.50. Reviewed in *Zement* (Germany), March 5, 1931, V. 20, No. 10, p. 226.—In a comprehensive treatise on construction of reinforced concrete arch bridges, numerous forms and systems are arranged according to different viewpoints. Examples of loading tests are of special value for consideration of questions of static. Construction and centerings are described besides presentation of static calculations.—A. E. BEITLICH

The use of pre-cast reinforced concrete slabs for bridge floors. RAFAEL CEBALLOS PARON. *Summary Reports First I. C. for C. and R. C.*—This

paper describes the arrangements for handling reinforced concrete slabs, precast in quantities off the site, for eventual use, suitably erected, to form the floor of a double track railway bridge of concrete.—LA TECHNIQUE DES TRAVAUX

Concrete trusses and 47-ft. flat slabs in new Seattle viaduct. CLARK H. ELDRIDGE. *Eng. News Record*, April 16, 1931, V. 106, No. 16, p. 642.—The West Garfield St. bridge recently completed in Seattle at a cost of about $750,000 includes heavy one-way flat slab construction on spans up to a maximum of 47 ft., and reinforced-concrete trusses 60 ft. long. Structure is 3010 ft. long, with a 36-ft. road and two 6-ft. walks. To meet design stress of 1200 lb. per sq. in., a 1:2:3 mix was used which attained an average 28-day strength of 3867 lb. per sq. in. Both trusses and deck were concreted in one operation.—GLENN MURPHY

Study of viaducts of variable span. G. GARAT. *Genie Civil*, (France) Jan. 31, 1931, No. 5, p. 109-114.—About 50 viaducts are under construction at present on the line Tanap—Thakhek, Indochina and consist of reinforced concrete spans resting on masonry supports. Spans vary from 19.7 ft. to 49.2 ft. Ease of construction and esthetic considerations have led to adoption of constant depth for all spans. Careful cost analysis including numerous diagrams representing cost per meter of the viaducts, showed that no appreciable cost increase was produced by adopting a constant depth.—M. A. CORBIN

Construction of a bridge over river Glan in Odernheim for highway between Homburg and Bingen (Germany). SEYWALD. *Zement* (Germany), Feb. 5, 1931, V. 20, No. 6, p. 125-9.—Old structure which had suffered by increased traffic during war time was replaced by reinforced concrete arch bridge. Sound underground was found in a depth of 20 ft. Span of single arch is 131.2 ft., roadway is 19.7 ft. wide and has a 4.1 ft. wide sidewalk on either side. Arch is provided with 3 lead hinges. Foundations were made in open excavations protected by Larsen steel sheet pilings. Centering is of normal design. Of special interest are expansion joints. A 1:4:8 concrete mix was used for abutments, 1:2:3 and 1:3:5:6.5 mixtures for arch and a 1:2:3 mix for roadway slab.—A. E. BEITLICH

Bridge piers in Suisun Bay supply test of concreting methods. C. R. HARDING. *Concrete*, April, 1931, V. 38, No. 4, p. 9-11.—To prevent shattering by earthquake, piers for railroad bridge, across Suisun Bay, at San Francisco, were heavily reinforced with steel rods. Concrete was controlled by W/C ratio method. Rock and sand were weighed, and cement, to which was added 3 per cent diatomaceous silica, was added from sacks. Adjustments were made for free water in aggregate. Concrete was mixed 90 seconds after all materials were in the mixer. Concrete mix, by weight, of 1:2.5:4.4, included 5 sacks of cement per cu. yd. and 6.75 gal. water per sack. Compressive strengths per sq. in. were 2,000 and 3,200 lb. at 7 and 28 da. Eight pedestal piers, located on land were built in wood forms, pier footings resting directly on bedrock. Mix was 1:2.42:4.04 by weight, with 5.46 sacks cement per cu. yd., and 6.25 gals. water per sack. Average compressive strengths were 1,760, 2,630, and 3,350 lb. at 7,14 and 28 da. Wood forms for 14 pedestal piers were built inside cofferdams and concrete placed in dry. Concrete for shafts was 1:2:3 mix by volume, with 6.49 sacks cement per cu. yd. of concrete, and 5.25 gal. water per sack of cement. Strengths were 2,700, 3,500 and 4,500 lb. per sq. in. at 7, 28, and 90 days.—C. BACHMANN

Reinforced concrete bridge with rigid reinforcement. *Genie Civil* (France), Feb. 7, 1931, No. 6, p. 139-141.—To reduce dead weight, bridge near Echelsbach, Bavaria, across the Ammer with a 426.5 ft. span, and rise of 104.3 ft. was designed as two arches of rectangular section, measuring 4.9 ft. in width and varying in depth from 6.56 ft. at crown to 10.5 ft. at skewback. These arches are spaced 19.7 ft. axis to axis and are hollow. Special feature of bridge is its reinforcement, which permitted erection without false work with independent

foundations. Bridge was erected cantilever fashion and was encased in concrete using light forms, this system of rigid reinforcement being known as Melan and Spangenberg system. Its application for a large span presented difficulty of ascertaining variable stresses produced by progressive concreting. Before concreting bridge was subjected to a load of gravel equivalent to total load it was finally to support, this load being removed as concreting progressed. —M. A. CORBIN

The Lorraine bridge over the river Aare in Bern (Switzerland). ROB MAILLARD. *Schweizerische Bauzeitung* (Switzerland), Jan. 3, 10, 17, 31, 1931, V. 97, No. 1, 2, 3 and 5, p. 1-3, 17-20, 23-6, 47-9.—Center arch of large concrete highway bridge has elliptical shape and span of 262.5 ft. Two circular arches with spans of 55.8 ft. support approaches on either side. Large concrete blocks, surfaces of which were treated by Contex method, were used. Abutments rest on sound rock. Roadway is provided with two cantilevered sidewalks, and is supported by 8 horizontal and 44 transverse concrete walls. Center and side arches are separated by expansion joints. Concrete mixing plants were located on either side of river. Centering of middle arch had unusual design. Placing of concrete blocks was started from both sides by cable crane. Data are furnished concerning physical tests of structural materials, laboratory tests, observations of movements in arch and temperature measurements.—A. E. BEITLICH

Repair of the Wallstrasse bridge in Ulm. K. SCHAECHTERLE. *Beton u. Eisen* (Germany), Jan. 5, 1931, V. 30, Heft 1, p. 14-18.—The Wallstrasse bridge (cf. *Bauzeitung* (Germany), 1906, Nos. 1, 7, 11) a three hinged open spandrel arch over the State Railroad built in 1905 has until recently given satisfactory service, with practically no maintenance cost. Clear span is 215 ft. with 187 ft. between the abutment hinges, and the rise 19 ft. The superstructure is 34 ft. wide. Arch concrete (stiff 1:3:5) showed a 57-day strength of 4800 lb. per sq. in. and the deck concrete (soupy 1:4¼) a 28-day strength of 2300 lb. per sq. in. In the last few years damp and wet spots appeared on the underside of the deck, water began to drip at the expansion joints and cracks and spalling became noticeable, particularly along the cantilevered side walk. Investigation revealed that slight changes in the original design would have prevented this deterioration. Where spalling had started, or where underspace of slab was wet, rusting of slab steel was found. In some places steel was exposed. Hair cracks and action of smoke led to much of rusting of reinforcement in portions above tracks. A lead and asphalt membrane used to water proof roadway, seems to have given fairly satisfactory service. Plain asphalt coating used for sidewalks proved inadequate due to cracking and to poor details along railing and curb. Damage was not serious enough to warrant expense of rewaterproofing the entire structure. Faulty joints along railing and curb were repaired and rusted steel was exposed and covered with fresh mortar. A groove was cut in the underside of sidewalk slab to act as a drip. Drains were provided along expansion joints. Paving was treated with a waterproof covering. After slabs were dry the entire soffit of deck slab received a waterproof coating. The following recommendations are made. Drainage should be promoted by covering upper surface of structure with a jointless asphalt coating or something similar. Both bearing surface and surface of structural slab should be given sufficient grade and lateral slope. Sliding plates over expansion joints should be avoided for ordinary spans. Percolated water should not be permitted to cross expansion joints. Waterproofing should not be given sharp bends and should be carried up a short distance at railing and curbs.—A. A. BRIELMAIER

BUILDINGS

Theatre and restaurant Des Ambassadeurs at Paris. L. GELLUSSEAU *Genie Civil*, Jan. 24, 1931, No. 4, p. 77-81.—Structure comprises a large dining room with stage and a theatre with 1000 seats. Work progressed rapidly due

to use of a skeleton of reinforced concrete. The structure is 85 by 207 ft. and is very low—21.5 ft.—to be in keeping with general character of the Champs Elysées. With exception of two steel trusses entire structure is of reinforced concrete. To reduce time of placing, only cement of high strength was used. Entire job was completed in less than three months, a record according to European standards. Live load used in the design was 495 lb. per sq. ft. Tests showed short-time placing of concrete in no way impaired its strength.—M. A. CORBIN

New high buildings in Duesseldorf (Germany). WILHELM PETRY. *Zement* (Germany), Jan. 22, 1931, V. 20, No. 4, p. 79-82.—(1) In the enlargement and reconstruction of tall reinforced concrete office building, basement structure was protected against ground water by insulation of interesting design and will stand a water head of 16 ft. Superstructure is of skeleton type consisting of one inner and one outer row of columns. Span of horizontal connecting beams is 23.8 ft. (2) Municipal bath house has 2 indoor swimming pools, 82 ft. by 36 ft. and 82 ft. by 41 ft. Both rest on separate reinforced concrete foundations to prevent harmful stresses in case building settles.—A. E. BEITLICH

The new structures of the Bavarian Dairy Co. in Nuernberg (Germany). HERMANN MEIER. *Zement* (Germany), March 19, 26, 1931, V. 20, No. 12-13. p. 274-8, 304-6.—Remarkable features of a number of reinforced concrete dairy structures include ceilings with very large spans. Main building is reinforced concrete skeleton structure, 354 ft. long and 79 ft. wide. Distances between reinforced concrete columns are 19.7 to 37.5 ft. Main roof has reinforced concrete ceiling with spans from 78.7 to 121.4 ft. without supporting columns. Building is provided with 3 expansion joints. Reinforced concrete chimney was erected by Heine method with sliding forms. Two water tanks having a total capacity of 42,000 gallons and arranged circumferentially around chimney, are supported by a circle of 8 reinforced concrete columns, 65.6 ft. high, connected by 2 horizontal concrete rings. Foundation consists of 5 ft. reinforced concrete slab, an octagon with outer diameter of 41 ft. High early strength cement was used for chimney construction.—A. E. BEITLICH

DAMS

Construction features of Osage hydro-electric development. *Eng. News Record*, March 26, 1931, V. 106, No. 13, p. 523-528.—Many interesting construction features are involved in Osage hydro-electric project near Bagnall, Mo. Power house forms 511 ft. of total length of dam, which is 2543 ft. Spillways constitute 520 ft. of crest. The maximum height is 148 ft. Concrete was made at central mixing plant, so located that 70,000 cu. yd. was chuted directly into place. Remainder was hauled in hoppers on flat cars over a construction bridge from which it was placed either by chutes or gantry crane. Four 60-cu. ft. mixers were used, giving a maximum 24-hr. output of 5082 cu. yd., with a 2-min. mixing period. The total yardage was 551,000.—GLENN MURPHY

Placing 350,000-cubic yards of concrete in Ariel dam. W. A. SCOTT. *Concrete*, March, 1931, V. 38, No. 3, p. 13-16.—Equipment for recovery of sand, gravel and cobbles from river deposit, washing and screening, bulk cement storage, proportioning and mixing, and conveying by belt was installed in construction of Ariel dam and powerhouse. Aggregate was transported 1000 ft. from river and dumped into bunker. Bulk cement was hauled 12 miles to storage. Water-cement ratio in mixer batch ranged from 0.9 to 1.0, including aggregate water. Concrete batches were discharged from mixers into 2-yd. bottom-dump buckets, carried on flat-cars and pulled alongside any section of dam, where buckets were lifted by crane or derrick. Expansion and contraction joints for all sections were placed at average of about 30 ft. Joints in arch section were 2 ft. wide, allowing arch to be built up in 30 ft.

sections, separated by 2-ft. slots, to be filled with concrete after shrinkage. Spillway contraction joints were grouted through series of pipes after shrinkage. —C. BACHMANN

Ariel dam—example of modern engineering practice. *Eng. News Record*, March 12, 1931, V. 106, No. 11, p. 435.—A site considered so difficult that 26,000-ft. of drill holes were put down to explore it, a foundation excavated 125 ft. through gravel to bed rock on site of ancient waterfall, and careful concrete control are among construction features of Ariel Dam of Inland Power and Light Co., on the Lewis River in Washington, about 40 miles northwest of Portland, Ore. The 313-ft. structure, with 1300-ft. crest, of thin-arch type requires 300,000 cu. yd. of concrete, 95,000 cu. yd. of which are in the one gravity abutment. Sand and gravel are excavated, washed, and screened on the site. Aggregate is graded to two sizes, ¼-1¼ in. and 1¼-3. Mix is 1:3.4:6.6 by weight, with w/c of 0.97, giving average compressive strength of 2,600 lb. per sq. in. at 28 days. Three 2-yd. mixers, with time of mixing 2½ min., enable workmen to average over 1.6 cu. yd. per min. of placed concrete. Concrete is placed in 12 in. layers in 5-ft. lifts in gravity section and in 10 ft. lifts in arch section. Vibration of concrete is accomplished by a steel shoe carrying a small portable gasoline engine with an eccentric flywheel. To reduce heat generated and resultant shrinkage stresses, the arched section of the dam is built in sections 30 ft. long separated by 2-ft. spaces to be filled six months later. Studies with electric thermometers indicate arrangement is most successful. Tests indicate rapid cooling may be obtained by circulating water through pipes cast in the block. It was found that concrete placed at 60° F. will rise to a maximum of 140° F. during curing process.—GLENN MURPHY

MISCELLANEOUS

Concrete and reinforced concrete in the Colony. M. DAVID. *Summary Reports First I. C. for C. and R. C.*—This paper discusses general conditions under which concrete and reinforced concrete are built in the (Belgian) colony—reasons why works in durable material, especially concrete, have to be adopted; conditions to be fulfilled; remarks on colonial materials (cements, sand, gravel, and in particular, laterite concrete); means and methods of execution; labor; and costs.—LA TECHNIQUE DES TRAVAUX

The application of concrete in the Belgian Congo. R. COPPEE. *Summary Reports First I. C. for C. and R. C.*—Special conditions governing the choice of concrete as material for construction in the Belgian Congo are: Climatic effects on works, other destructive agents peculiar to tropical regions, delivery time and costs for other materials, poor quality of other materials.—LA TECHNIQUE DES TRAVAUX

The manufacture of pre-cast reinforced concrete pieces on the Belgian National Railway Co. C. LEMAIRE AND J. SCHOTTE. *Summary Reports First I. C. for C. and R. C.*—Organization of a work yard. Quality and specifications of raw materials. Description of the various operations involved in the manufacture. Descriptions of the articles manufactured and of the shuttering used in quantity production.—LA TECHNIQUE DES TRAVAUX

Experimental study and description of constructional elements in reinforced concrete. LOUIS BAES. *Summary Reports First I. C. for C. and R. C.*—(1) Farco metal as a material for centering and as reinforcement. Farco metal is formed of very thin steel sheets specially formed with projecting sides giving a certain stiffness. These sides are joined by a trellis with a mesh sufficiently small to retain the concrete. (2) Experimental study and description of reinforced concrete tubes made by rolling and intended to resist bending (process Tubarsi). The note describes the process of fabrication by rolling of tubes of concrete heavily reinforced longitudinally.—LA TECHNIQUE DES TRAVAUX

Special reinforced concrete piles. M. E. H. TJADEN. *Summary Reports First I. C. for C. and R. C.*—The "de Waal" system is as follows: hollow cylin-

drical pile is built of reinforced concrete and driven into ground down to a hard stratum; working through hollow an enlarged foot is formed; then the inside is filled with concrete. The piles may either be formed in situ or precast in pieces about 8 ft. long.—LA TECHNIQUE DES TRAVAUX

A casting operation of reinforced concrete piles. J. VILAR. *Summary Reports First I. C. for C. and R. C.*—Bridge required 800 reinforced concrete piles about 32 ft. 10 in. long, and as the space available for casting them was confined to 164 x 66 ft., a procedure had to be devised whereby they might be superimposed. This was effected by placing sheets of thick paper between adjacent piles to prevent bonding with one another, thus taking up the least possible space.—LA TECHNIQUE DES TRAVAUX

New methods of forming piles cast in situ. L. F. DE JESSEN. *Summary Reports First I. C. for C. and R. C.*—Foundation piles cast in situ are perfectly adapted to nature of soil and varied forces which a foundation must resist. Three solutions recently applied are: (1) Drawing of the tube with or without an interior stopper; (2) reinforced inclined piles cast in situ: (3) piles with a base cast in situ surmounted by a pre-cast shaft.—LA TECHNIQUE DES TRAVAUX

Investigation of the effect of frost on concrete with special consideration of the insulating effect of molds. ADALBERT POGANY. *Zement* (Germany), March 12, 1931, V. 20, No. 11, p. 246.—Tests were made with 3 in. concrete cubes. Molds consisted on 3 sides and bottom of 1-in. boards. Fourth side was exposed to temperatures of − 7.6° F. and could be provided with boards of ½ in. to 1¼ in. thickness. Thermometers were located at various places in concrete and temperatures were plotted. Different curves were obtained only during first 30 minutes; afterwards no differences could be noted with boards of different thickness. Exothermic process in concrete such that insulating properties of boards are of minor importance.—A. E. BEITLICH

Hastings promenade widening works. *Engineering* (England), April 3, 1931, V. 131, No. 3403, p. 446.—In rebuilding shore promenade at Hastings a sea wall was built at outer line by driving two rows of watertight sheet steel piling between which, after excavation, a concrete wall of "Sal Ferricite" was placed. This wall has a curved face and is finished off with a larger radius nosing to break force of the waves. Steel rails were used for reinforcement.—G. M. WILLIAMS

Pre-cast caisson impounding wall at Weston-Super-Mare. *Engineering* (England), April 10, 1931, V. 131, No. 3404, p. 477.—To increase bathing facilities at Weston-Super-Mare an artificial lake has been created on the beach to impound flood tide. A heavy wall was required to withstand strong gales together with high tides. Caissons of reinforced concrete 20 ft. long 12 ft. wide and 9 ft. high with the interiors divided into four equal portions by longitudinal and transverse wells were built with rapid hardening Ferrocrete cement in a sheltered cove and floated into position and sunk by filling compartments with sand. A 1:1½:3 concrete mix was used. Before floating caissons into position a base was prepared by excavating pits in shore sand and refilling with mass concrete and boulders; these pits being spaced so that each served to support adjoining ends of two caissons. Space of several feet between caisson ends was filled with mass concrete in which Stanton spun concrete sluice pipes were cast. After placing caissons the height was increased 2 ft. by addition of concrete blocks. A sloped retaining wall, rising at an angle of 30 deg. made up of boulders and faced with a thick layer of boulder concrete was placed on sea side of caissons with toe protected by sheet piling.—G. M. WILLIAMS

New ocean terminal at Halifax, N. S. *Canadian Engineer*, Feb. 10, 1931, V. 60, No. 6, p. 22.—Pier B unit recently constructed in Halifax Harbor consists of 30 reinforced concrete cribs, with depth of water varying from 35 to 45 ft. at low tide. Cribs are 108 ft. long, 52 ft. wide and 53 ft. 6 in. high for outer 18 and the same length but width of 42 ft. and depth of 42 ft. 6 in. for inner 12.

Special construction dock having a water depth of 35 ft. at low tide was built. Cribs were started on pontoons and after a certain height was built were launched and completed while floating. After completion these were towed to position and sunk by letting water into pockets. Cement Fondu, imported from England was used.—G. M. WILLIAMS

Cement calendar 1931. "Zement Kalender 1931." RIEPERT, 1930, Zementverlag, Charlottenburg, (Germany), RM. 3.60. Reviewed in *Bautechnik* (Germany), March 20, 1931, V. 9, No. 13, p. 198.—A few new additions to this book include special concreting methods, new application of concrete pump (Pumpkret-method). Chapters on cement pipes, concrete wells, cement roof tiles and concrete slabs for sidewalks are enlarged.—A. E. BEITLICH

Swimming pool at Chateau Laurier. *Canadian Engineer*, Feb. 29, 1931, V. 60, No. 8, p. 11.—Canadian National Railway has completed a modern swimming pool as part of therapeutic department at Hotel Chateau Laurier at Ottawa. Pool is 25 ft. wide, 60 ft. long and from 3½ to 9 ft. deep, lined with mosaic tile and lighted under water. Reinforced concrete was cast as a unit to avoid weakness at joints.—G. M. WILLIAMS

Physics for construction technique. "Bautechnische Physik." HIMMEL-STROH-MEYER, 1930, B. G. Teubner, Leipzig and Berlin (Germany), sixth edition, R. M. 5.40. Reviewed in *Zement* (Germany), March 5, 1931, V. 20, No. 10, p. 226.—This book treats physics from standpoint of construction practice and shows examples of physical reactions and of physical installations for construction work.—A. E. BEITLICH

Government grain elevator at Prescott. E. SMITH, *Canadian Engineer*, April 7, 1931, V. 60, No. 14, p. 19.—A 5,000,000-bushel terminal grain elevator, erected at Prescott, Ont., by Dominion Government, has length of 1285 ft. and width of 70 ft. made up of 125 circular tanks with an internal diameter of 20½ ft., and 190 interspace tanks. The height is 85 ft. and wall thickness 7 in. After driving piling and cutting them to grade an 18 in. thick reinforced concrete mattress was placed.—G. M. WILLIAMS

Concrete blocks supplant ties in experimental track. *Eng. News Record*, March 26, 1931, V. 106, No. 13, p. 514.—Track construction without ties, but with pairs of reinforced-concrete blocks connected by tiebars, is being tried on a practicable scale in Italy, and is to be applied more extensively. Blocks are 24x44 in. on the base, and 36x16 in. on top, top surface being sloped 1 in 20 to give the rail an inward cant. The thickness is 8 in. on outer side. Rail rests on a metal plate, under which is a ½-in. wood cushion block. Fastenings are provided so gage is adjustable.—GLENN MURPHY

Concrete units hold embankments. *Concrete Products*, March, 1931, V. 40, No. 3, p. 36-37.—Construction of an unusual retaining wall, involving use of approximately 48,000 5x8x12-in. concrete building tile furnished by San Angelo Building Material Co. was completed recently at plant of the West Texas Utilities Co., San Angelo, Texas. This retaining blanket is approximately 50x410 ft. and has a wall area of over 20,000 sq. ft. Panels, measuring about 10x12 ft. each laid on a 30 deg. slope, are tied together with reinforced concrete beams formed of same tile to prevent settlement of areas greater than 120 sq. ft. In this retaining wall, which protects a spray pond located near a small stream, concrete tile was bid on and placed for $1.35 per sq. yd. less than bid for rip-rap.—E. S. HANSON

Precast concrete pipe supports. *Conc. Building Conc. Prod.*, (England), April,1931, V. 6, No. 4, p. 1.—Reinforced concrete pipe trestles, consist of two raking columns, with two or more horizontal bracing members. Longest trestles are molded first, molds being cut short at level of top of one of braces, and a new end piece fixed. The concrete mix is 1:2:4, with rapid hardening cement. Trestles are from 7 ft. 6 in. to 20 ft. overall, and the heavier ones are lifted by shear legs after four or five days. They are slung into position from top and upper brace. Bottom of trestle is buried 1 ft. below ground level in a block of concrete. Another type of trestle consists of three units; footing, pre-

cast column of variable length and standard cap, precast or cast in situ Pyramidal footings are reinforced each way. A 9-in. recess is formed to receive column. A projecting tongue, specially reinforced, forms a key with reinforced concrete cap, which is afterwards grouted on.—JOHN E. ADAMS

Vibration—a new method of working concrete. M. BERENGIER. *Genie Civil* (France), Feb. 21, 1931, No. 8, p. 189-192.—Vibration of forms has given way to vibration of concrete mass itself, a process, which in France is designated as "pervibration." Apparatus generally consists of a shell, within which is enclosed vibrator proper, made of special steel, and operated with compressed air. This vibrator is immersed in the concrete, which acquires the properties of a liquid. When the vibrator is removed, no trace is found of its former location. In general, working of 1.3 cu. yd. may be effected with expenditure of 2 hp. hr. as recorded by compressor. A floating vibrator designed and used successfully on construction of concrete columns, is placed in the form and concrete poured. It rises with each successive pouring. Forms should be watertight. Advantage of vibrating process is elimination of uncertainties inherent in working concrete by hand. Tests made at the Laboratoire des Ponts et Chaussées demonstrate that high strengths may be obtained through vibration with poor mixes, strength, permeability and compactness tests yielding satisfactory results. Great possibilities for ornamental effects are afforded by vibrated concrete, in which the mortar coating of aggregate is very thin, and a compact mosaic effect is produced. Additional expenditures in using a vibrator are: purchase or renting of a vibrator; increased volume of aggregate, corresponding to increased compactness of concrete; watertight forms. Economy of this method results in: reduction of quantity of cement used through higher strengths obtained, which allow reduction of sections; elimination of all hand labor in working concrete; elimination of all finishing work due to very smooth surface.—M. A. CORBIN

Passenger quay "Stazione Marittima" in Triest (Italy). L. GSCHWEND. *Schweizerische Bauzeitung* (Switzerland), Jan. 24, 1931, V. 97, No. 4, p. 35-8.—New quay was connected with old structure by means of hinges to allow room for settling of old wall. Difficulties were encountered in driving reinforced concrete piling which supports 17 reinforced concrete piers of new structure. Piles were 17 in. in diameter and up to 72.2 ft. long. High grade steel tubing, 55.8 ft. long and 19.7 in. in diameter, with a smaller inner steel tubing (end of which was provided with pointed chrome-nickel steel head) were driven through 16 ft. layer of loose rocks. After reaching sound rock inner tubing was pulled and reinforced concrete pile made of high early strength cement was driven. Reinforcements consisted of 8 longitudinal rods and ¼ in. spiral windings. Molds were assembled on shore and concrete of piers was placed under water. Pozzuolana was added to mixture.—A. E. BEITLICH

Continuous conveying as an advancement in construction methods. E. RATHSMANN. *Beton u. Eisen* (Germany), March 20, Apr. 5, 1931, V. 30 Heft 6, 7, p. 117-121, 134-137.—A detailed review gives names of makers of typical machines and some figures on performances of continuous conveying methods for earth, aggregate, concrete etc. Belts and steel bands, in trough form, are suited for moving aggregates and concrete along a 16 to 20 deg. slope with a speed of 4 to 6.5 ft. per second. Troughs and pipes are employed in forwarding concrete, and vibrating troughs for moving dry materials. Conveyors for any slope include bucket chain excavators pneumatic conveyors and pumps. Fuller-Kinyon and Torkret machines are pneumatic conveyors. The former used chiefly for moving cement, depends on intimate mixing of material with air stream and latter is used for moving by means of air pressure, dry mixed concrete materials. The use of compressed air to convey fine concrete, mortar and grout, in a wet state, for cement gun work is widespread. Torkret system of pneumatic transportation of concrete calls for a dry mix, which is dropped into a pressure chamber and forwarded by compressed air through pipes (4 to 6 in. diam.) to discharge chamber where water is added and high velocity of dry

mix is vitiated by impact. Pumps for forwarding materials without the use of water as a vehicle present the latest and simplest method for granular and powdery materials with a small water content. Concrete with aggregate up to 1 in. can be pumped 330 ft. horizontally and 135 ft. vertically. This method almost revolutionizes concrete construction practice and often eliminates lifts, towers and belts.—A. A. BRIELMAIER

Details of movable forms and their operation. RICHARD T. MCKAY. *Concrete*, April, 1931, V. 38, No. 4, p. 12-14.—Forms for 8 concrete tanks with inside diameter of 29 ft. 9 in., walls 7 in. thick and 100 ft. high, have top diameter slightly larger and bottom diameter smaller. Mean thickness of wall 2 ft. from top is 7 in. Top of upper ring of segments is kept down $5\frac{5}{8}$ in. so 2x6 in. joists space 16 in. center to center for supporting 1 in. decking can rest directly on them. Three rings of 2 by 8 in. segments, both top and bottom, are spiked together and laid so that, in their lengths, they lap each other. Staves are nailed to segments. I-beams over each row of tanks are set in moving forms and carried up with them to support roof slab over completed tank walls and also to support 2 by 6 in. joists that carry 1 in. decking placed over entire inside area of tanks. Deck is used for storage of bars placed as work proceeds, and is concreting deck. Exact placing is not necessary of jack rods. To pull between 60 and 70 sq. ft. of forms to each jack, spacing of 8 ft. is suggested. With forms 4 ft. deep on each side of wall, this spacing would give 64 sq. ft. of contact area to be pulled by each jack.—C. BACHMANN

Concrete mixture design controlled by Chicago & North Western. O. F. DALSTROM. *Concrete*, April, 1931, V. 38, No. 4, p. 21-24.—Instructions for designing concrete mixtures issued for information of its contractors and for use of its engineering and inspection forces by Chicago and North Western Railway are as follows: Form BD-1 is to be used whenever concrete is made. One copy completely filled out is to be sent to engineer of bridges as soon as concrete work is started, or before. The source of the aggregates should be determined and recorded on form. Soundness and colorimetric tests are recommended when value of aggregates is doubtful. Aggregates must satisfy specification requirements as to structure and cleanness. Concrete is noted on plans as Class A, B, or C. For Class A, strength at 28 days should be 3,000 lbs. per sq. in., requiring a maximum of $5\frac{1}{2}$ gals. of water per bag of cement; Class B, 2500 lbs., with $6\frac{1}{4}$ gals. of water; Class C, 2000 lbs., with 7 gals. of water. Representative sample of aggregate is to be taken about a foot in from surface and half-way up stock-pile. Grading is next determined and entered, followed by field mix by volume and net quantity of mixing water. Yield is determined without calculations by reading scale. After mix design is complete, check should be made by trial batch, workability of which is measured by slump method. After concrete operations are under way, frequent determination of the moisture content of aggregates should be made and adjustment made at the mixer.—C. BACHMANN

Chicago and North Western instructs inspectors of concrete. O. F. DALSTROM. *Concrete*, March, 1931, V. 38, No. 3, p. 30-32.—At inauguration of controlling quality of concrete in field, railroad required own engineering and inspection forces to attend Portland Cement Association course of instruction on subject. Course has been repeated every spring since. Written instructions to inspectors form next step. Included are emphasis on w/c ratio method, list of specifications, directions, references and blank forms inspector should carry, list of equipment contractors and railway construction crews should have on job. Specific duties of inspectors are outlined in ten paragraphs.—C. BACHMANN

New quay walls in Hamburg (Germany), discussed from constructive and economic view point. K. BARITSCH. *Report 33rd main meeting German Concrete Association*, March 17, 1930, p. 430-67.—A great number of new harbor structures are described in all details, with drawings, graphs, and static calculations, and costs of similar structures are compared. Following rein-

forced concrete structures are included: (1) Quay wall for Deutsche Werft, A. G., consists of 2 sections which are 820 and 666 ft. long. Latter part supports 80-ton traveling crane which reaches 165 ft. (2) Similar structure was built for wharf of Blohm and Voss. (3) Quay for Rhenania-Ossag Oil Co., shows interesting design (cf. *Zement* (Germany), Jan. 8, 1931, V. 20, No. 2, p. 39-40). (4) Reinforced concrete quay wall on east side of harbor in Cuxhaven (Germany). Detailed cost calculations are given.—A. E. BEITLICH

Dustproof concrete floors. *Conc. Bldg. Conc. Prod.* (England), March 1931, V. 6, No. 3, p. 42.—Concrete floors when properly prepared and laid should stand heaviest traffic without serious trouble from dusting or disintegration. Main causes of a dusting surface are: foreign matter in the aggregates; too much cement or fine aggregate; too wet or too dry mix; excessive trowelling; exposure of surface to action of frost; too rapid drying of surface; practice of sprinkling surface with neat cement. The finished surface should always be kept damp for 7 days at least, and increased resistance to wear may be obtained by treating surface with solution of sodium silicate. A 30.5 per cent solution of neutral sodium silicate diluted with about 4 times its volume of water, well brushed over floor and application repeated after 24 hr. has given good results. A vegetable oil such as tung oil may be applied neat, or diluted with turpentine or white spirit and freely applied, excess being wiped off after 2 hr. A second application is sometimes necessary if floor is very porous.—JOHN E. ADAMS

The eight-mile Cascade tunnel of the Great Northern Railway. A symposium. D. J. KERR, FREDERICK MEARS AND J. C. BAXTER. *Proc. Am. Soc. C. E.*, Feb., 1931, V. 57, No. 2, p. 184-268.—Symposium constitutes final professional record of this project and consists of Part 1, an historical outline; Part 2, a description of the surveying methods; and Part 3, detailing methods of construction. This 7.79 mile tunnel (longest railroad tunnel in the Western Hemisphere and fifth longest in the world) replaces a 2.7 mile tunnel completed in December, 1900, and which lowered the Cascade crossing from 4,059 to 3,383 ft. elevation and replaced temporary 4 per cent switchback grades over pass to 2.2 per cent. Tunnel is single track on a 1.565 per cent grade down to the west, concrete lined throughout and was completed in 3 years. The excavated section varied from 18 ft. wide by 25 ft. high to 22 ft. wide by 27 ft. 6 in. high. The tunnel is 16 ft. by 22 ft. 10 in. inside the concrete lining throughout. Excavation proceeded through a pioneer bore supplemented by a 622-ft. shaft in Mill Valley. This shaft cut the tunnel into lengths of 2.41 and 5.38 miles. Center heading followed by top heading and bench excavation was used. None of granitic tunnel muck was suitable for use in concrete lining and entire concreting operation was carried on via east and west portals. On account of conduits side walls were poured in two lifts. Concrete was mixed near the points of deposition. Sand and gravel bunkers equipped with batching devices were constructed near portals. Proportions were nominally 1:2:4, varied to meet variations in the aggregate. Diatomaceons earth was used. A special Blaw-Knox traveling steel form permitted the lining of 37.5 ft. of tunnel at each move. Travelers for form also carried a 14-cu. ft. concrete mixer and air placer and various chutes and elevators. The arch ring was placed pneumatically (cf. H. J. King in Appendix B of paper, p. 261-268). There were 8 of these form placers, 3 of which were operated from west portal and 5 from the east portal. As work progressed removal of forms was shortened from 48 hr. to as low as 8 hr. after final placement, without sign of injury to concrete. The highest rock temperature encountered was 75 deg. (115 deg. had been estimated) and concrete reached 93 deg. about 2 days after placement, cooling gradually to rock temperature after about 2 months. Total yardage of concrete lining was about 275,000.—H. J. GILKEY

Vibrated concrete coating protects underground pipe lines. *Concrete*, March, 1931, V. 38, No. 3, p. 23-24.—Water-cement ratio of 4¾ gal. to sack of cement was disclosed as proper mixture for vibrated concrete for coating underground pipe in studies in Portland Cement Association laboratory. Mixture of 1 part portland cement, 1½ parts well graded sand (0 to ¼ in.) and 3 parts of gravel (¼ to ⅜ in.) was made with 4¾ gal. of water per sack of cement. Mixture appeared dry and unworkable, but was readily placed in forms and around pipe with the use of electrically operated vibrator. Mixture was placed on 10 ft. section of 8⅝-in. O. D. pipe, making concrete covering 1¾ in. thick. Two piece form was made of No. 14 gauge galvanized sheet metal. American Steel and Wire Co., No. 12 welded wire fabric reinforcement, 2 by 6 in. was placed around pipe and held half way between pipe and form. Vibrator was fitted to top of form and operated as concrete was inserted. No honeycombing or segregation of materials resulted. Forms were removed in 24 hr. and concrete cured under damp burlap for 14 days.—C. BACHMANN

Public baths, Westminster. *Ferrocrete Snowcrete Bul.* (England), March, 1931, No. 22, p. 5.—Two swimming baths and over 100 slipper baths, offices, laundry, etc., are included in new reinforced concrete structure at Westminster. Floor of larger bath, which is 100 ft. by 35 ft. and 10 ft. deep at one end, is supported on longitudinal ferro concrete beams, resting on sleeper walls, carried down to firm foundations, and at 16 ft. centres. Additional support is given by columns. Side walls are finished by platform or footway, and floor, which is first covered with asphalt, and walls are lined with Sicilian marble. Staging for spectators is in ferroconcrete and the dressing boxes at gallery level can be folded back to form a dado, and give extra floor space. Smaller bath, which is 70 ft. by 30 ft. is similar except that it is lined with tiles and nosing and scum trough are white glazed fireclay. Roof is semi-circular barrel arch, carried by eight arch ribs springing from foundation slabs below basement level. Clear span is 68 ft. Tubular steel scaffolding was employed to support the timber centering for rib and concrete was mixed at street level and raised in skips by hoist crane at crown of arch. Mix for structural members was 11 cwt. Ferrocrete, 13½ cu. ft. sand and 27 cu. ft. ¾-in. Thames ballast. The mix for walls had only 6 cwt. cement.—JOHN E. ADAMS

Dome built of glass tiles. CRAEMER. *Beton u. Eisen* (Germany), Feb. 20, 1931, V. 30, Heft 4, p. 72.—In the construction of the Indo China Pavilion of French Colonial Exposition several transparent roofs were used. One of domes was built of square glass tiles 15 in. on edge by 3¼ in. thick. Tiles are separated by narrow reinforced concrete ribs, but are so shaped that the dome presents an all glass undersurface and concrete ribs are not noticeable. The dome has the form of a paraboloid of revolution with a diameter of 39.8 ft. and a rise of 4.1 ft. Necessary variation in width of ribs was too small to be evident. Horizontal thrust of dome was taken by a reinforced concrete ring, supporting members being subjected only to the vertical reaction of the dome. Forms consisted of frames with parabolic upper chords spaced at 15 in. Glass tiles were first placed on these open forms and reinforcement and concrete were then placed in spaces between tiles. Parabolic frames were used several times. Several slabs without curvature, were built with same type of glass tiles. These slabs spanned openings as large as 14 ft. 9 in. by 14 ft. 9 in. with a live load of 102 lb. per sq. ft.—A. A. BRIELMAIER

Precast concrete in sea defense work. *Conc. Bldg. Conc. Prod.* (England), Feb., 1931, V. 6, No. 2, p. 21.—Precast concrete units are being used in construction of new sea defense wall and promenade at Bridlington. A new 40-ft. promenade is carried between mass concrete sea wall 1500 ft. long and 16 ft. high, faced with precast concrete units, and existing coast. Reinforced concrete shelters are formed on the inner side of new promenade, with 8 or 9-in. reinforced concrete roof slab carried on 12 by 9-in. beams at 12 ft. 6 in. centres. Beams are supported on back wall and precast columns on front. Columns

are 11 by 11 in. for the lower third of their height and taper to 9 by 9 in. at top. Bases are 15 by 15 in. high, and ornamentally reduced to section of base of column. Similarly ornamented caps are cast on columns. Pine molds were made on the site by the contractors and handled by loco. crane. Reinforcement projects well out of the cap for bonding into beams. Wall facing blocks are composed of 1:2:4 mix, aggregate being obtained from the beach. The seaward faces have a 9 in. facing of concrete made with crushed granite chippings. Blocks ranged from 6 ft. 6 in. by 2 ft. 6 in. by 1 ft. to 3 ft. 6 in. by 2 ft. 6 in. by 1 ft. The upper edges are beveled on the face, each course being stepped back 8 in. at the lower joints to 4½ in. at the top. Triangular recesses are provided in the sides for keying purposes. The promenade paving slabs are 3 ft. by 3 ft. 3½ in. by 4 in. thick, and are made alongside the site on timber molds capable of taking two slabs. The bottom 3 in. of slab is mixed in proportion of 6 parts beach gravel to 1 part portland cement. The 1-in. facing is made with 4 parts crushed granite and black sand to 1 part cement, to eliminate glare. Four recesses are cast on the lower edges of the slab to simplify lifting and transport, and sheets of mesh reinforcement are inserted to prevent cracks.—JOHN E. ADAMS

Screw piles and cylinders. *Magazine Tecnico* (Argentina), Sept.-Dec., 1930.—The screw pile and cylinder are not new but until recently they were impracticable because of complicated equipment required. Usual forms are (1) solid steel piles about one foot in diameter united in lengths of 15 ft. and used for docks, (2) screw cylinder made in diameters up to 4 ft. and lengths of 10 ft. Material is removed as cylinder is lowered and then cylinder is refilled with concrete. (3) Concrete pile with a screw shoe of steel, screw being driven by a steel shaft running through center of concrete. Exterior of the concrete shell is protected by light steel plates. This type is filled with concrete after the drive shaft is removed. Screw piles have screw with diameter about twice that of pile which gives them a greater bearing area. They can be put down and tested and then unscrewed if location is found unsatisfactory. The Braitwaite Co., Ltd., London, have adapted electric capstan to placing of screw piles and cylinders so that now they can be placed to depths of a 100 ft. with rapidity and economy. Electric capstan consists of a framework of steel on which electric motor and reduction gears are mounted. Cylinders are made of steel or cast iron and where diameter is large enough, internal unions are used. The section of the screw or helix is calculated considering screw as a curved cantilever under uniform load using the formula $f = \frac{3\,W\,(R+r)\,(R-r)^2}{\pi\,r\,t^2\,R^2}\left(1 - \frac{(R+2r)}{(3R+r)}\right)$ where f = stress at point where helix joins the cylinder. W = load on cylinder. R = exterior radius of helix. t = thickness of the helix at point where it joins the cylinder. The pitch of the helix depends on (a) the material on which the helix is to work, (b) the rate of penetration necessary, (c) the power available in the capstan. The best efficiency is obtained at a velocity of between ½ and 1 revolution per minute of the screw. The power required for the capstans is between 5 h. p. for the small piles and 30 h. p. for the cylinders 10 ft. in diameter. Cost is much lower than for foundations or caissons placed by other methods.—C. G. CLAIR AND M. N. CLAIR

ROADS AND PAVEMENTS

Field determination of cement content of paving concrete. H. ALLEN. *Eng. News-Record*, March 26, 1931, V. 106, No. 13, p. 513.—For determining cement content of mixes proportioned by weight, field equipment consisting of a cast-aluminum measure with a capacity of ½-cu. ft., platform scales, a rod, and a trowel has proven satisfactory. When a standard method of tamping and weighing sample is followed, actual amount of cement in a given sample can be determined quite accurately.—GLENN MURPHY

Concrete roads in Belluno (Italy). *L'Industrie Italiana del Cemento* (Italy), 1930, No. 10; reviewed in *Ostr. Bauzeitung* (Austria), Feb. 14, 1931, V. 7, No. 7, p. 84-5.—Extreme care and construction control is absolutely necessary for good results. Eight sections of highway were built with concrete of varying composition. Road foundation consisted partly of old underground, partly of 6 in. concrete layer. Wire netting was imbedded in concrete. Mixtures contained 440 to 770 lb. cement per 35.31 cu. ft. Reinforcements were prepared by patented special method. Street will be subject to inspections from time to time.—A. E. BEITLICH

Bituminous surfaced concrete sidewalks. A. W. HADDOW. *Canadian Engineer*, March 31, 1931, V. 60, No. 13, p. 19.—City of Edmonton, Alberta, has developed a bituminous surfaced concrete walk consisting of a 4-in. base of 2500-lb. concrete topped with a 1-in. sheet asphalt mixture. Concrete is placed in the usual manner after grading and placing forms with side and transverse retaining shoulders built up to finished surface. Asphalt surface is rolled in place between shoulders several weeks later. Cost is 30c per sq. ft., including all charges.—G. M. WILLIAMS

WATERWORKS

Filtration plant at Brantford, Ont. F. P. ADAMS, *Canadian Engineer*, Feb. 17, 1931, V. 60, No. 7, p. 15.—Brantford, Ont., has completed construction of new pumping and filtration plant, the latter consisting of six 100,000 gallon gravity type rapid sand filters together with mixing chamber, sedimentation basins and filtered water storage reservoir. To insure watertightness a concrete mix of 1:1½:3 was used. The roof of pumphouse and filter building was made of Haydite concrete.—G. M. WILLIAMS

Filters and pumping station connected by concrete conduit. WM. C. MABEE. *Eng. News Record*, April 23, 1931, V. 106, No. 17, pp. 690-692.—Following completion of second large conduit connecting White River filters of Indianapolis Water Co. to Riverside pumping station, careful leakage tests indicated an extremely tight line. Results were more interesting in that conduit passes under Fall Creek and was laid in water-bearing sand and gravel, dewatered with well points. Line is of precast reinforced concrete, consisting of 4400 ft. of 60-in., and 700 ft. of 54-in. copper-bell pipe, in 12½-ft. lengths, 6 in. thick. Pipe was cast in steel forms, with flanged sheet-copper cylinder in pipe bell to provide for expansion and to take up inequalities of grade. The circumferential reinforcement was designed for a head of 25 ft., and longitudinal reinforcement comprised 0.22 per cent of shell area. The concrete was 1:1½:2½, and pipes were moist cured.—GLENN MURPHY

Water purification plant at Ottawa, Ont. A. D. STALKER, *Canadian Engineer*, Feb. 10, 1931, V. 60, No. 6, p. 15.—Work was started in 1929 on a water purification plant having an initial capacity of 35 million gallons daily. Plant, covering an area of 384 by 342 ft. consists of mixing tanks, settling basins and filters together with a filtered water reservoir of concrete. Mix having a slump of 3 to 4 in. with 4.9 to 5.1 gal. of mixing water per bag of cement resulted in strength of 3000 lb. per sq. in. at 28 days. Concrete walls were cured by sprinkling from a ½ in. pipe, perforated at 1 ft. intervals, placed above wall. Flat surfaces were cured by covering with sawdust kept moist by sprinkling. All concrete was kept wet for 14 days.—G. M. WILLIAMS

The use of separated sizes of coarse aggregate in the proportioning of concrete for highway construction. R. W. CRUM. *Nat. Sand Gravel Bull.*, Feb., 1931, V. 12, No. 2, p. 48-52.—Use of coarse aggregate separated into two or more sizes in construction of concrete pavements has been found to be feasible. It does not unduly complicate operations and added cost is small.

Two things can be accomplished by shipping coarse aggregate in two or more sizes and combining them at batching plant. (1) A better grading, having lower void percentage, may be secured than would be possible by taking run of pit. (2) Evil of segregation of sizes in stock piles and cars can be minimized, thus assuring delivery of more uniformly graded aggregate to individual batches. Whether or not this will result in more uniform concrete depends upon importance of coarse aggregate grading in particular concrete mixture being used. From a study of costs of materials and handling, effect of batch size upon cost, workability, durability, and strength and uniformity, it appears that separated sizes of coarse aggregate can be used with uniformity in results if coarse aggregates are furnished in several sizes: and that mixtures with an excess of mortar can be used to produce uniform results without dependence upon control of aggregate grading. An advantage of use of mixtures containing higher percentages of mortar is ease with which workability can be maintained without extra precautions. The controlling factor in choice of type of mixture under specific conditions is largely that of economy in composition of concrete.—P. McKIM

Silicate of soda street foundations. LUIGI BASCHIERI. *Le Strade*, Dec., 1930, V. 12, No. 12, p. 429-440.—Good results have been obtained, in comparison with macadam, with street foundations constructed with calcareous materials and silicate of soda in accordance with the rules given by Guelle of France based on his experiments in 1922. The mix consists of about 1 cu. yd. of graded calcareous stone up to 2 in. combined with ⅓ cu. yd. of calcareous sand or dust resulting from crushing stone and approximately 10 gal. of 35° Beaume sodium silicate. At present experiments are being made to investigate the effect of the variation in proportions on the characteristics of this sodium silicate concrete. A calcareous rock and a quartz rock were used in mixtures with sodium silicate solutions of various densities and compression specimens made from these mixtures were tested at several ages up to 60 days. Limestone aggregate was much superior to the quartz and mixtures with aggregate graded below ⅜ in. were better than those with excess of larger, or smaller aggregate.—C. G. CLAIR AND M. N. CLAIR

SHOP MANUFACTURE

Concrete garden frame. F. BURREN. *Conc. Build. Conc. Prod.* (England), April 1931, V. 6, No. 4, p. 76.—A design for a reinforced concrete garden frame is illustrated, and its advantages outlined. Vibration of concrete into position is recommended, and also a mix of 1:1½:3 with ⅜-in. crushed granite —JOHN E. ADAMS

Precast concrete factory at Liverpool. *Conc. Building Conc. Prod.* (England), April, 1931, V. 6, No. 4, p. 71.—Main features of products, and a description of the nature of recent contracts carried out by a well known firm of precast concrete manufacturers, is given, and illustrated.—JOHN E. ADAMS

"Eternit-Durasbest" and its application in the building industry. H. GROSSMAN. *Zement* (Germany), March 5, 1931, V. 20, No. 10, p. 221-4.—A new type of asbestos cement is used in manufacture of slabs and pipes. Eternit-Durasbest is made of a mixture of 1 part of asbestos and 6 to 7 parts of portland cement. Slabs are made 4 by 8 ft. Excess water is removed under hydraulic press. Pipes can be manufactured in various sizes and thickness of walls is made according to desired pressures.—A. E. BEITLICH

The modern way of manufacture of asbestos-cement pipes. E. LECHNER. *Zement* (Germany), March 12, 1931, V. 20, No. 11, p. 247-50.—A

comprehensive review of publications and patent literature on manufacture of asbestos-cement pipes. Detailed description of methods and installations are given and advantages and disadvantages are described. Methods are also judged from economic viewpoint. Special consideration is given to asbestos-cement pressure pipes, manufacturing methods and their application. Spinning of asbestos pipes resulted in very porous product not suitable for high pressures. Great differences in specific gravities of cement and asbestos cause considerable separation of constituents during spinning process.—A. E. BEITLICH

Profitable manufacture of concrete building units. FRED A. SAGER. *Concrete*, April, 1931, V. 38, No. 4, p. 17-20.—Several methods of handling raw materials are given to illustrate analysis of cost of this part of plant operation. Three methods include placing raw materials in storage by hand, by elevator with bins on ground, and with full elevated bins. In case taken as example, handling operations from car to mixer are (A) shoveling from car to pile, and (B), shoveling and wheeling in wheelbarrows or wheel cart from storage to mixer. Labor rate of 75c per hour, gives cost of 12.5 cents per 1,000 lb. for putting cinders into storage piles. For handling sand or stone as aggregate, suitable labor performance, applicable to those materials, should be used. For wheeling from storage pile to mixer, with 2¼ cu. ft. wheelbarrows, an average run of 50 ft. is taken. Time for filling one wheelbarrow is 40 sec., wheeling, dumping and returning 60 sec., or at a rate of 36 trips per hour, which moves 81 cu. ft., or 4,500 lb. per hour, at a cost of 16.66 cents per 1,000 lbs. Proper runways are effective in reducing cost of operations.—C. BACHMANN

Modern manufacture and use of concrete products and artificial stone. VON MENG. *Beton u. Eisen* (Germany), Oct. 20, 1930, V. 29, Heft 20, p. 357-362.—Modern concrete products have attained their present importance because of the simplicity of manufacture and freedom possible in selection of shape, size and adaptability. Methods of mix design employed in heavy concrete construction cannot be applied to concrete products without some changes. Very thorough study of materials and proportions is essential before production is begun. Fundamental theory, such as that concerning the effect of quantity of water, is same as for mass concrete. In addition to the usual sand gravel and stone, and the natural light weight stones, pumice, lava and tuff there are artificial aggregates including slag, cinders, artificial pumice, porcelain grits, cork, asbestos, treated sawdust, wood wool and others. Selection of aggregate is governed by properties desired in the product; flexibility, compressive, tensile or bending strength, fire resistiveness, impermeability, insulation against heat, sound and electricity, etc. In many cases these properties may be further increased by addition of substances having a chemical or physical effect, as for instance in manufacture of porous concrete. Type of cement and method of concreting have a bearing on resulting properties of the product. Concrete may be poured, vibrated, compressed, squirted or centrifugally cast. Outstanding development is centrifugally-cast pipe, (in Germany mainly Vianini, Dywidag and Hume pipes). These have been replacing to a large extent the welded and riveted iron pipes and wooden pipes. A recent addition is "asbestos cement pipe" (Asbestzenrentrohr) with 2 to 4 in. inside diameter, capable of withstanding 220 lb. per sq. in. pressure and a worthy competitor of iron, steel and cast iron pipes. It is cheaper than metal pipes, light in weight, has a high elasticity and is tough, is a non-conductor of electricity and is not affected by salts or acids within certain limits. Use of concrete for posts, trolley poles, street light poles, etc., has opened up a large field, especially for the centrifugally-cast pole. Concrete paving tiles are cast under 5150 lb. per sq. in. pressure, in pieces 14 by 14 by 3 in. and placed on a subpavement of 1:12 concrete 1¼ to 2 in. thick. Joints were filled with cement grout. Concrete blocks and artificial stone are well adapted to remodeling. —A. A. BRIELMAIER

New Oklahoma pipe plant. DUDLEY W. MOORE. *Concrete Products*, March, 1931, V. 40, No. 3, p. 22-24.—Plant of Oklahoma Cement Pipe Co., Tulsa, Okla. has a daily capacity of 60 to 70 tons of manufactured products of which storm sewer pipe is principal product. Sizes range from 12-in. to 60-in. diameter, made on a machine of revolving platform type. Octagon steel storage bin with five compartments for the storage of stone, sand and cement has capacity of 800 tons. At the top of bin is a turntable distributing device controlled by a wheel and bevel gears from the batching floor beneath the bin so that separate sizes of material are delivered to the various compartments. Discharge is by gravity through a gate into a weighing batcher. Company also manufactures transit mixed concrete.—E. S. HANSON

Betonwerkstein (cast stone). FRIESECKE. *Betonwerk* (Germany), Feb. 28, 1931, No. 9, V. 19, p. 113.—Subject is divided into eight parts: (1) Development of manufacture, selection and use of various aggregates, methods of fabrication and evolution of present designation; (2) cast stone is defended, it is not an imitation; (3) it is a suitable building material, it is strong, withstands weather and is beautiful; (4) present day knowledge of portland cement and concrete mixtures coupled with skill of fabricators is guarantee of good quality; (5) long list of meritorious installations from year 1869 to the present are listed in details; (6) law against willful disparagment of another's product is quoted; (7) observations of experiences of American cast stone manufacturers cited; (8) economy in use of cast stone. Artisans in technique of fabrication are being trained. No pains are being spared in overcoming prejudices and placing cast stone in high place it deserves.—H. FRAUENFELDER

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DETROIT, MICHIGAN

American Concrete Institute

Board of Direction

President

D. A. Abrams (Term expires 1932)

Vice-Presidents

S. C. Hollister (Term expires 1933)
Arthur R. Lord (Term expires 1932)

Secretary and Treasurer

Harvey Whipple (Term expires 1932)

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First District—R. B. Young (Term expires 1932)
Second District—Cloyd M. Chapman (Term expires 1932)
Third District—J. C. Pearson (Term expires 1933)
Fourth District—P. H. Bates (Term expires 1933)
Fifth District—F. R. McMillan (Term expires 1933)
Sixth District—Raymond E. Davis (Term expires 1932)

Past Presidents

Richard L. Humphrey Deceased (1905-14)
Leonard C. Wason (1915-16)
William K. Hatt (1917-19)
*Henry C. Turner (1920-21)
*William P. Anderson (1922-23)
*A. E. Lindau (1924-25)
*M. M. Upson (1926-27)
*E. D. Boyer (1928-29)

*The five latest, living past presidents are members of the Board

Institute Objects, Organization and Committees

The American Concrete Institute had its beginning in 1905 with organization (incorporated District of Columbia 1906) as the National Association of Cement Users. In 1913 its charter was amended with change of name. With a membership of about 2500 it maintains a continuous program in studying the properties of concrete and reinforced concrete and their constituent materials; considerations of concrete design, manipulation, application, service. Its aims are to increase the knowledge of concrete and to extend the use of that knowledge. It maintains no laboratory, employs no field force. The product of its work is in papers, committee reports and in discussions of them—correlating the experience of many agencies, public and private.

The Institute holds an annual convention as a forum for the presentation and discussion of outstanding developments in the theory and practice of its field, publishes the Journal of the American Concrete Institute monthly, except July and August. The Journal is in three sections: *News Letter*, for the news of the society and informal contributions tending to stimulate its technical program; *Proceedings* for technical papers, reports, discussions; *Abstracts*, consisting of digests of the current periodical literature of cement and concrete.

Proceedings have been published each year beginning 1905; in 1913, 1914, 1915 (Vols. 9, 10 and 11) these were issued periodically in Journal form. A return to the annual volume was made in 1916 with Vol. 12.* Completing Volume 25 in June 1929, Journal publication was again undertaken, No. 1 of Vol. 26 being issued in November, 1929.

The work of the organization is governed by the Board of Direction with 15 members (see By-Laws) and administered by the Secretary, appointed by the Board.

The Board divides the labors of formulating details of the creative program among three major committees: Advisory, originating technical committee assignments; Program, develop-

ing the annual convention; Publications, in general charge of the JOURNAL, which is edited by the Secretary. These committees report to the Board for approval of their undertakings.

In all of this the Institute constitutes a clearing house for the information of and for its chosen field. It is dependent on many public and private agencies and the work of individuals whose studies produce the data for which the Institute offers channels of dissemination and a forum for critical consideration and discussion.

Board of Direction and Executive Committee

The Board of Direction meets at the time of the annual convention; again in the spring (usually early May) and in the Fall (usually the first week of October). Between meetings its authority is vested in the executive committee consisting of the President, Secretary and three other Board members, named by the Board:

D. A. ABRAMS
E. D. BOYER
S. C. HOLLISTER
M. M. UPSON
HARVEY WHIPPLE

*Vol. 11, 1915 is incomplete, numbers 9 to 12 of that year never having been issued. Several numbers of the *Journal* for 1913, 1914 and 1915 are out or print as are also a few of the early volumes of *Proceedings*. Of the *Journals*, Nov. and Dec. 1913; Jan., Feb., Mar. 1914; and Jan., Feb., Mar., Apr., May, June, July and August 1915 are available and are for sale at 50 cents each. A limited supply of annual volumes, 2, 6, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22, so far as available are for sale to non-members at $8.00 each; Vol. 23, 24 and 25 at $10.00 each. The member price for available volumes to and including Vol. 25, 1929, is $5.00 each.

The new JOURNAL is sent to all members (paid for by an allotted portion of the annual dues). Members and JOURNAL subscribers desiring a complete bound copy of Volume 27, containing the *Proceedings* and *Abstracts* sections from the monthly JOURNAL (September 1930 to June 1931), in *addition* to the JOURNAL periodically, may buy it at $6.00. To non-members the price is $12.50.

Orders received from members or subscribers before September 1, 1931 for Volume 28 (September 1931-June 1932) will be filled at a special price—(not to exceed $3.50)—not more than two to each member. The Institute quotes this special price on orders received before the first JOURNAL issue of the volume, because it then knows the actual number of orders to be filled and can provide enough extra copies of each month's JOURNAL to make up the required number for binding. **After September 1, the price will be $6.00 to members,** because such orders must be filled from a limited reserve stock.

Advisory Committee

The Advisory Committee has 13 members: a Chairman, Secretary, the chairman of each of the nine departments of the Committee organization; together with the chairmen of the Program and Publications Committees:

ARTHUR R. LORD
Chairman

F. R. MCMILLAN
Chairman Department 100, Research

R. W. CRUM
Chairman Department 200, Materials

A. W. STEPHENS
Chairman Department 300, Engineering Design

REXFORD NEWCOMB
Chairman Department 400, Architectural Design

MILES N. CLAIR
Chairman Department 500, Specifications

R. B. YOUNG
Chairman Department 600, Field Construction

W. D. M. ALLAN
Chairman Department 700, Shop Manufacture

RAYMOND E. DAVIS
Chairman Department 800, Use Requirements

F. H. JACKSON
Chairman Department 900, Joint Efforts

P. H. BATES
Chairman Program Committee

W. A. SLATER
Chairman Publications Committee

For several years an advisory committee has simplified the work of the Board of Direction (which under the By-Laws creates all committees, assigns their tasks and names the chairmen) by presenting to the Board recommendations as to technical committee studies and personnel.

In February 1929 the Board adopted a new committee plan and in several important details a new procedure. It did away with "standing committees" in the usually accepted sense. In general it avoided assignments to "fields of interest." Committees are created for one year and their membership appointed for one year. Assignments, for the most part are to definite tasks.

The nine department representatives on the Advisory committee, are to serve as "eyes" in their respective fields of interest upon developments, both active and potential, which demand Institute attention. As members of the Advisory committee they contribute to the formulation of recommendations to the Board in reference to the Institute's technical committee program. One or more other representatives (co-chairmen) are also named for each department, and while these additional representatives are not members of the Advisory committee they are looked to for suggestions to the Advisory committee as to the technical committee work.

It is the responsibility of the Advisory committee, to recognize the elements of unsolved problems, to systematize their solution in recommendations as to definite committee tasks and to seek out the men best fitted to the various studies to be undertaken.

If committee changes in personnel or assignment or new committee tasks seem desirable the department representatives are expected to suggest these changes for consideration of the Advisory committee as a whole, all of which work is made the basis of recommendations to the Board.

Thus the Advisory Committee (whose chairman and secretary serve as the executive group between meetings) will recommend to the Board the organization of committees, their assignments and chairmen, and to the President their membership, and will coordinate and systematize the Institute's technical committee activity.

Committee departments do not imply definite boundaries of interest and responsibility. Obviously department interests overlap. The function of a department is important in its *viewpoint*. The Research department brings to bear a research viewpoint upon a matter which may also be of interest in every other department. The viewpoint of the department has its bearing on each definite committee task.

A committee department represents a division of the subject matter of the field *only* with respect to a *viewpoint*. Its assignment is exclusive only in viewpoint. Committees in turn are assigned to definite tasks in which their department viewpoint is reflected.

In general the new committee organization now functioning successfully for two years, comprehends the use of larger total personnel than heretofore; the study and systematization of a much larger list of subjects; small working units; more definite and limited assignments; much quicker action; more general discussion and the recognition of individuals as "authors" of reports.

The immediate ends sought are:

(1) An Institute with a much larger and usefully active personnel.

(2) A monthly JOURNAL of outstanding importance in its service to every kind of activity in the field of concrete.

(3) The summarization of existing information and adaptation to form for more general use—with an American Concrete Institute Manual of Practice as an objective.

(4) A more energetic pursuit of needed information to fill gaps in existing knowledge by encouraging tests and field studies.

A considerable number of committees are set up under a plan which frankly recognizes that in many instances much of a committee's work is actually being done by one man. Numerous small "working units" have been—many others will be formed. One man will be named "author." He may or may not be chairman of the committee or working unit. He will be assigned the task of writing a report. Other members will be named as "critics."

Critic members of committees have two functions: suggesting to the author revisions in the original draft and writing independent discussion of the subject under assignment. A report from the author type of committee represents the views of a committee majority when a majority are at once in agreement or by consent of the author in making revisions. Otherwise it is the report of an individual. Thus the Institute provides a hearing for strong independent

views and brings them into the general forum (whether convention or JOURNAL or both) rather than submerging such independent views in the compromise of a majority report.

Program Committee

The Program Committee's work is to select from among papers and reports submitted to the Institute such contributions as will make, in the judgment of the committee, either a well rounded program or one which deliberately stresses definite subjects of interest, for the annual convention. The acceptance of contributions by the Publications committee is entirely independent of the convention and in no way commits the Program committee as to their use on the convention program. It is anticipated that the JOURNAL will publish papers, reports and discussion considerably in excess of the requirements of conventions. The Program committee's selection of a contribution for the program in no way implies that it is of greater value than others not so selected. Some contributions are better read by members from the printed record; often highly technical contributions of great value are poorly adapted to oral presentation and impromptu discussion. When the Program committee selects material the Publications committee will defer to its preference in publication before or after the convention presentation. The Program committee:

P. H. BATES
Chairman

HARVEY WHIPPLE
Secretary

S. C. HOLLISTER

A. E. LINDAU

ARTHUR R. LORD
Chairman Advisory Committee

W. A. SLATER
Chairman Publications Committee

Publications Committee

The Publications committee has the responsibility of the technical publications of the Institute and invites original papers furthering the objects of the society and discussions of published papers and reports. It passes upon the papers and the reports of committees submitted for publication. All contributions are received through the Secretary who is the editor of the JOURNAL and Secretary of the committee. The committee will make all reasonable effort to advise authors promptly as to availability of contributions for publication—subject to consideration by appointed critics to whom manuscript copies are submitted for their advice to the Publications committee. The Program committee is deferred to in all matters which that committee selects for the annual convention program. The Publications committee:

W. A. SLATER
Chairman

HARVEY WHIPPLE
Secretary

J. C. PEARSON

A. N. TALBOT

BENJAMIN WILK

ARTHUR R. LORD
Chairman Advisory Committee

P. H. BATES
Chairman Program Committee

Abstracts

The maintenance of the JOURNAL section of Abstracts (presenting digests of periodical literature of cement and concrete) is a part of the responsibility of the Publications committee involving a special labor of considerable detail which has been reassigned as the special task of the Committee on Abstracts, each of whose members is responsible for a division of the field. More than 100 technical publications are regularly scanned by a corps of abstractors. These contributions are edited by Dwight F. Jennings, with the advice and assistance of the committee:

J. C. WITT
Chairman (Materials)
H. F. GONNERMAN
(Properties of Concrete)
F. E. RICHART
(Engineering Design)
REXFORD NEWCOMB
(Architectural Design)
THEODORE CRANE
(Field Construction)
W. D. M. ALLAN
(Shop Manufacture)

Technical Committees

The technical committee organization as of July 1, 1931, is as follows:

DEPARTMENT 100—RESEARCH

To comprise all committee work in which the principal interest is in the interpretation of test data or the initiation or direction of tests.

Chairman—F. R. McMillan
Co-Chairmen—H. J. Gilkey and F. E. Richart

Committee 102—Volume Changes in Concrete

Author-Chairman—G. E. Troxell
Raymond E. Davis, H. J. Gilkey, Charles C. More

Committee 103—Effect of Curing Conditions

Author-Chairman—A. A. Anderson

Committee 104—Permeability of Concrete

Author-Chairman—L. G. Lenhardt

Ira L. Collier
Charles H. Scholer
R. H. Schroeder
M. O. Withey

Committee 105—Reinforced Concrete Column Investigation

Chairman—W. A. Slater

P. H. Bates
R. L. Bertin
F. R. McMillan
F. E. Richart
W. S. Thomson
W. F. Zabriskie

Committee 106—Effect of Vibration on Properties of Concrete

Author-Chairman—R. F. Leftwich

Committee 107—Properties of Job-Cured Concrete at Early Ages

Author-Chairman—Harlan H. Edwards

R. W. Crum
H. E. Davis
T. E. Stanton
M. A. Timlin

Committee 108—Properties of Mass Concrete

Chairman—Raymond E. Davis

P. H. Bates
R. W. Carlson
J. P. Crowdon
E. C. Eaton
F. W. Hanna
W. C. Hanna
G. W. Hawley
D.C.Henny
Louis C. Hill
W. L. Huber
G. W. Hutchinson
S. E. Hutton
H. L. Jacques
F. R. McMillan
S. B. Morris
W. A. Perkins
J. L. Savage
B. W. Steele
G. E. Troxell
A. J. Wiley
C. P. Williams
Hubert Woods

Committee 109—Plastic Flow

Author-Chairman—Raymond E. Davis

Hardy Cross
J. R. Shank

Committee 110—Use of Admixtures in Concrete

Author-Chairman—Ben Moreell
Vice-Chairman—Rex L. Brown

Committee 111—Effect on Concrete of Repeated and Reversed Loads

Author-Chairman—H. H. Scofield

Committee 112—Resistance of Concrete to Impact

Author-Chairman—W. M. Dunagan

Committee 113—Bond Stress

Chairman—F. E. Richart
Secretary—J. R. Shank

H. J. Gilkey
H. F. Gonnerman
T. G. MacCarthy
G. A. Maney
W. A. Slater
Albert Smith

Committee 114—Relations of Cement Content, Strength, Water-Ratio and Durability

Author-Chairman—L. W. Walter

F. R. McMillan
R. B. Young

DEPARTMENT 200—MATERIALS

To comprise all committee work in which the principal interest is that of the production and distribution of materials used in concrete work.

Chairman—R. W. Crum
Co-Chairmen—E. O. Sweetser and R. W. Johnson

Committee 201—Aggregate Specifications

Chairman—H. F. Clemmer

R. L. Bertin
A. T. Goldbeck
Fred Hubbard
F. H. Jackson
Herbert F. Kriege
H. J. Love
H. S. Mattimore
N. C. Rockwood
Stanton Walker
L. E. Williams

Committee 203—Cinders as Aggregate for Concrete

Author-Chairman—Einar Christensen

W. D. M. Allan
R. D. Bradbury
Miles N. Clair
Emil Praeger
George A. Strehan

Committee 204—Burned Clay or Shale Aggregates

Author-Chairman—George E. McIntyre

E. W. Dienhart
Iver Erickson
V. P. Jensen
R. F. Leftwich
A. B. Shenk
W. P. Stanton

Committee 205—Grading Aggregates for Handling on the Job

Author-Chairman—I. E. Burks

G. D. Durham
Alexander Foster
A. E. Stoddard

Committee 206—Welded Wire Fabric as a Reinforcing Material

Author-Chairman—R. D. Bradbury

DEPARTMENT 300—ENGINEERING DESIGN

To comprise all committee work in which the principal interest is that of the structural design or of the supervision of construction of such work.

Chairman—A. W. Stephens
Co-Chairmen—Hale Sutherland and H. N. Howe

Committee 304—Fire Resistance Standards in Design

Author-Chairman—N. D. Mitchell

R. L. Bertin
R. W. Johnson
F. R. McMillan
T. D. Mylrea

Committee 305—Structural Loads and Reductions in Design

Author-Chairman—R. L. Bertin

Peter L. Hein
H. N. Howe
George Thompson

Committee 307—Deflections of Reinforced Concrete Members

Author-Chairman—T. D. Mylrea

P. J. Freeman
Fred Kubitz
A. H. Saurbrey

Committee 308—Basis of Design for Hurricane Exposures

Author-Chairman—Albert Smith

D. C. Coyle
Hardy Cross
W. J. Knight
G. A. Maney
L. E. Ritter
W. C. Spiker

Committee 309—Minimum Permissible Thickness of Slabs and Walls

Author-Chairman—D. E. Parsons

Committee 310—Effect of Settlement of Foundation in Reinforced Concrete Structures

Author-Chairman—Hardy Cross

Committee 311—Moment of Inertia of Reinforced Concrete Members

Author-Chairman—F. E. Richart

M. B. Lagaard
G. A. Maney
Hale Sutherland
L. C. Urquhart

Committee 312—Plain and Reinforced Concrete Arches

Author-Chairman—Charles S. Whitney

DEPARTMENT 400—ARCHITECTURAL DESIGN

To comprise all committee work in which the principal interest is that of the architectural design or of sculpture or of the supervision of such work.

Chairman—Rexford Newcomb
Co-Chairman—O. F. Johnson

Committee 404—Composite Concrete Structures

Author-Chairman—J. Morrow Oxley

Committee 405—Economics of Tall Building Design

Author-Chairman—R. R. Zipprodt

S. C. Hollister
A. W. Stephens

Committee 406—Use of Light Weight Concrete in Buildings

Author-Chairman—Frank A. Randall

Frank Brown
W. S. Wolfe

Committee 407—Painting on Concrete Surfaces

(undergoing reorganization)

Committee 408—Recommended Practice for Use of Color in Concrete

Author-Chairman—W. D. M. Allan

J. G. Ahlers
Joseph W. Ayers
C. A. Cooke
John Mott
Rexford Newcomb
M. R. Rust
Edward M. Waldo

DEPARTMENT 500—SPECIFICATIONS

To comprise all committee work in which the principal interest is that of the production of specifications for material, services or workmanship on behalf of the owner.

Chairman—Miles N. Clair
Co-Chairman—P. J. Freeman

Committee 501—Standard Building Code

Chairman—A. W. Stephens
Secretary—R. R. Zipprodt

R. L. Bertin
H. P. Bigler
R. B. Bradbury
Frank E. Brown
A. E. Lindau
Arthur R. Lord
F. R. McMillan
N. D. Mitchell

Miles N. Clair
Theodore Crane
Hardy Cross
S. C. Hollister
H. N. Howe
R. W. Johnson
T. D. Mylrea
F. E. Richart
W. A. Slater
Hale Sutherland
W. S. Thomson
L. C. Urquhart
R. B. Young

Committee 502—Mixing and Placing Concrete in Buildings

Author-Chairman—Arthur R. Lord
A. S. Douglass
A. B. MacMillan
J. Thumley
W. F. Way

Committee 503—Fabricating and Setting Reinforcing Steel

Author-Chairman—W. F. Zabriskie
R. L. Bertin
R. W. Johnson
A. R. Lord
W. S. MacKenzie
W. S. Thomson

Committee 504—Specifications for Ready-Mixed Concrete

Author-Chairman—Miles N. Clair
Alexander Foster, Jr.
P. J. Freeman
Frank I. Ginsberg
R. S. Greenman
W. E. Hart
C. E. Nichols
H. F. Thomson
Stanton Walker
R. B. Young

Committee 505—Reinforced Concrete Chimneys

Author-Chairman—E. A. Dockstader
William Jassoy
E. R. Maurer

Committee 506—Concrete Specifications for the Small Job

Author-Chairman—Arthur R. Lord
Theodore Crane
P. J. Freeman
S. C. Hollister
W. F. Way

507—Purchase Specifications for Metal Supports for Reinforcement

Author-Chairman—W. E. White

Committee 508—Concrete Foundations for Steel Buildings

Chairman—J. E. Hough

DEPARTMENT 600—FIELD CONSTRUCTION

To comprise all committee work in which the principal interest is that of monolithic construction, including job equipment, organization, etc.

Chairman—R. B. Young
Co-Chairmen—R. C. Johnson, Nelson L. Doe

Committee 601—Measuring Materials for Concrete

Author-Chairman—R. B. Young
I. E. Burks
A. A. Levison
H. C. Ross

Committee 602—Developing Latent Strength of Concrete

Author-Chairman—H. F. Gonnerman

Committee 603—Design and Operation of Central Mixing Plants

Author-Chairman—Frank I. Ginsberg
Joseph E. Burke
Miles N. Clair
N. D. Crowley
G. L. Lucas
A. W. Munsell
H. F. Thomson
Fred C. Wilcox

Committee 604—Winter Concreting Methods

Author-Chairman—R. C. Johnson
I. E. Burks
W. S. McNaughton
L. J. Street
R. B. Young
Nelson L. Doe

Committee 605—Settlement of Concrete In Forms

Author-Chairman—James Lindon

Committee 607—Use of Cement in Bulk

Author-Chairman—Herbert Coffman
Peter F. Stauffer
Malcolm H. Ulman
A. G. Watt
Fred C. Wilcox

Committee 608—Sliding Formwork

Author-Chairman—L. Boyd Mercer

John H. Heindel
W. R. Sproul
Edmund Wilkes, Jr.

DEPARTMENT 700—SHOP MANUFACTURE

To comprise all committee work in which the principal interest is that of the manufacture and distribution of factory made concrete products.

Chairman—W. D. M. Allan
Co-Chairmen—C. F. Buente, C. A. Wiepking

Committee 701—Standards for Concrete Masonry Units

Chairman—Benjamin Wilk
Secretary—R. E. Copeland

Nolan Browne
Einar Christensen
E. W. Dienhart
C. J. Herzog
D. E. Parsons
George O. Payne
A. G. Swanson

Committee 702—Prevention of Crazing

Author-Chairman—P. H. Bates

F. O. Anderegg
E. D. Boyer
John J. Earley
J. C. Pearson

Committee 704—Cast Stone Standards

Chairman—Louis A. Falco
Secretary—C. G. Walker

P. H. Bates
George J. Eyrick
Herman Fraunfelder
J. W. Lowell
Ernest Rackle
C. Van de Bogart

Committee 705—Weather Resistance of Concrete Masonry Units

Author-Chairman—C. A. Wiepking

W. D. M. Allan
Einar Christensen
Dan F. Servey

Committee 706—Concrete Pipe

Chairman—W. J. Schlick

Committee 708—Recommended Practice for the Manufacture of Concrete Masonry Units

Chairman—P. M. Woodworth

E. W. Dienhart
C. J. Herzog
M. I. McCarty
Eugene F. Olsen
W. P. Stanton
Stanton Walker

Committee 709—Specifications for Concrete Burial Vaults

Chairman—W. D. M. Allan

C. A. Berg
H. F. Hanneman
Carl Head
H. A. Ledyard
F. J. Mead
Harry Samson
J. A. Stuart
F. H. Van Ness
C. A. Wiepking

DEPARTMENT 800—USE REQUIREMENTS

To comprise all committee work in which the principal interest arises from the requirement of unusual or special qualities in concrete on account of its use in less common construction or where subject to extraordinary exposures.

Chairman—Raymond E. Davis
Co-Chairman—W. F. Way

Committee 801—Durability of Concrete

Chairman—A. E. Lindau
Secretary—F. R. McMillan

P. J. Freeman
G. F. Loughlin
E. Viens
L. W. Walter
R. B. Young

Committee 802—Portland Cement Floor Finish

Chairman—John G. Ahlers
W. E. Hart — Millard F. Bird

DEPARTMENT 900—JOINT EFFORTS

To comprise all committee work done by the Institute jointly with representatives from other societies and work in which the principal interest is clearly in two or more of the foregoing departments.

Chairman—F. H. Jackson
Co-Chairman—Cloyd M. Chapman

Committee 901—Concrete Culvert Pipe Standards

Chairman Institute Representation—B. S. Pease
F. F. Longley

Committee 902—Concrete Pavement Standards

Chairman—F. C. Lang

Committee 903—Joint Committee on Specifications for Concrete and Reinforced Concrete

Chairman Institute Representation—S. C. Hollister
J. G. Ahlers — Ben Moreell
F. H. Jackson — N. M. Stineman

Committee 904—A. C. I. Representation Sectional Committee on Plastering

J. C. Pearson

Committee 905—A. C. I. Representation Sectional Committee on Specifications for Portland Cement

J. G. Ahlers — E. D. Boyer
W. K. Hatt

(Announcements of committee changes, of the completion of committees not now fully organized and of new committees will be made from time to time in the JOURNAL —*News Letter* section.)

By-Laws

American Concrete Institute

ARTICLE I

Members

Sec. 1. Any person engaged in the construction or maintenance of work in which cement is used, or qualified by business relations or practical experience to cooperate in the purpose of the Institute, or engaged in the manufacture or sale of machinery or supplies for cement users, or a man who has attained eminence in the field of engineering, architecture or applied science, is eligible for membership.

Sec. 2. A firm or company shall be treated as a single member.

Sec. 3. Any member contributing annually twenty or more dollars in addition to the regular dues shall be designated and listed as a Contributing Member.

Sec. 4. Application for membership shall be made to the Secretary on a form prescribed by the Board of Direction. The Secretary shall submit monthly or oftener, if necessary, to each member of the Board of Direction for letter ballot a list of all applicants for membership on hand at the time, with a statement of the qualifications, and a two-thirds majority of the members of the Board shall be necessary to an election.

Applicants for membership shall be qualified upon notification of election by the Secretary and by the payment of the annual dues, and unless these dues are paid within 60 days thereafter, the election shall become void. An extract of the By-Laws relating to dues shall accompany the notice of election.

Sec. 5. Resignations from membership must be presented in writing to the Secretary on or before the close of the fiscal year and shall be acceptable provided the dues are paid for that year.

Sec. 6. The Board of Direction may confer honorary memberships in recognition of services of an extraordinarily meritorious character before the Institute. Honorary members shall be entitled to full membership privileges without the payment of dues.

ARTICLE II

Officers

Sec. 1. The officers shall be the President, two Vice-Presidents, six Directors (one from each geographical district), the Secretary and the Treasurer, who, with the five latest living Past-Presidents, who continue to be members, shall constitute the Board of Direction.

Sec. 2. The Board of Direction shall, from time to time, divide the territory occupied by the membership into six geographical districts, to be designated by numbers.

Sec. 3. There shall be a Committee of five members on Nomination of Officers elected by letter ballot of the members of the Institute, which is to be canvassed by the Board of Direction at least six months prior to the Annual Convention. The President, Vice-President, Secretary, Treasurer and the Directors from the six geographical districts shall be ineligible for membership on this committee.

The Committee on Nomination of Officers shall select by letter ballot of its members, candidates for the various offices to become vacant at the next

Annual Convention and report the result to the Board of Direction who shall transmit the same to the members of the Institute at least 120 days prior to the Annual Convention. Upon petition signed by at least ten members, additional nominations may be made within 60 days thereafter. The consent of all candidates must be obtained before nomination. The complete list of candidates thus nominated shall be submitted 60 days before the Annual Convention to the members of the Institute for letter-ballot, to be canvassed at 12 o'clock noon on the second day of the Convention and the result shall be announced the next day at a business session.

Sec. 4. The terms of office of the President, Secretary and Treasurer shall be one year; of the Vice-Presidents and the Directors, two years. Provided, however, that at the first election after the adoption of this By-Law, a President, one Vice-President, three Directors and a Treasurer shall be elected to serve for one year only, and one Vice-President and three Directors for two years; provided, also, that after the first election a President, one Vice-President, three Directors and a Treasurer shall be elected annually.

The term of each officer shall begin at the close of the Annual Convention at which such officer is elected, and shall continue for the period above named or until a successor is duly elected.

A vacancy in the office of President shall be filled by the senior Vice-President. A vacancy in the office of Vice-President shall be filled by the senior Director.

Seniority between persons holding similar offices shall be determined by priority of election to the office, and when these dates are the same, by priority of admission to membership; and when the latter dates are identical, the selection shall be made by lot. In case of the disability of or neglect in the performance of his duty of any officer of the Institute, the Board of Direction shall have power to declare the office vacant. Vacancies in any office for the unexpired term shall be filled by the Board of Direction, except as provided above.

Sec. 5. The Board of Direction shall have general supervision of the affairs of the Institute and at the first meeting following its election, appoint a Secretary and from its own members a Finance Committee of three; it shall create such special committees as may be deemed desirable for the purpose of preparing recommended practice and standards concerning the proper use of cement for consideration by the Institute, and shall appoint a chairman for each committee. Four or more additional members on each special committee shall be appointed by the President, in consultation with the Chairman.

Sec. 6. It shall be the duty of the Finance Committee to prepare the annual budget and to pass on proposed expenditures before their submission to the Board of Direction. The accounts of the Secretary and Treasurer shall be audited annually.

Sec. 7. The Board of Direction shall appoint a Committee on Resolutions to be announced by the President on the first regular session of the annual convention.

Sec. 8. There shall be an Executive Committee of the Board of Direction, consisting of the President, the Secretary, the Treasurer and two of its members, appointed by the Board of Direction.

Sec. 9. The Executive Committee shall manage the affairs of the Institute during the interim between the meetings of the Board of Direction.

Sec. 10. The President shall perform the usual duties of the office. He shall preside at the Annual Convention, at the meetings of the Board of Direction and the Executive Committee, and shall be ex-officio member of all committees.

The Vice-Presidents in order of seniority shall discharge the duties of the President in his absence.

Sec. 11. The Secretary shall be the general business agent of the Institute, shall perform such duties and furnish such bond as may be determined by the Board of Direction.

Sec. 12. The Treasurer shall be the custodian of the funds of the Institute, shall disburse the same in the manner prescribed and shall furnish bond in such sum as the Board of Direction may determine.

Sec. 13. The Secretary shall receive such salary as may be fixed by the Board of Direction.

ARTICLE III

Meetings

Sec. 1. The Institute shall meet annually. The time and place shall be fixed by the Board of Direction and notice of this action shall be mailed to all members at least thirty days previous to the date of Convention.

Sec. 2. The Board of Direction shall meet during the Convention at which it is elected, effect organization and transact such business as may be necessary.

Sec. 3. The Board of Direction shall meet at least twice each year. The time and place to be fixed by the Executive Committee.

Sec. 4. A majority of the members shall constitute a quorum for meetings of the Board of Direction and of the Executive Committee.

ARTICLE IV

Dues

Sec. 1. The fiscal year shall commence July 1st.

Sec. 2. The annual dues shall be twelve dollars and fifty cents ($12.50) payable annually in advance from the first of the month following notification of the applicant of his election by the Board of Direction.

Sec. 3. Each member shall be entitled to receive one copy of one volume of the Proceedings for each membership year and additional volumes at a price fixed by the Board of Direction.

Sec. 4. A member whose dues remain unpaid for a period of three months shall forfeit the privilege of membership and shall be officially notified to this effect by the Secretary, and if these dues are not paid within thirty days thereafter his name shall be stricken from the list of members. Members may be reinstated upon payment of all indebtedness against them upon the books of the Institute.

ARTICLE V

Standards

Sec. 1. Proposed new or revised Standard Specifications, Standard Practice, and Standard Definitions when approved by a majority voting in the committee in which they originate, shall be submitted, in the form adopted in the Standard Form of Standards, to the secretary of the Institute 60 days prior to the opening of the annual convention at which they are to be presented. The secretary of the Institute shall cause these proposed new standards or revised standards to be printed as Proposed Tentative Standards and mailed to the full membership of the Institute thirty days prior to the opening of the convention. As there amended and approved, they shall be published in the Annual Proceedings, next issued as Tentative Standards. At a subsequent annual convention, they may again be offered unamended, by their originating committees as proposed standards, and as there approved by a majority of those voting, they shall be submitted to letter ballot of the Insti-

tute membership, to be canvassed within ninety days thereafter. Such proposed standards shall be considered adopted unless at least 10 per cent of those voting shall vote in the negative.

ARTICLE VI

Amendments

Sec. 1. Amendments to these By-Laws, signed by at least fifteen members, must be presented in writing to the Board of Direction ninety days before the Annual Convention and shall be printed in the notice of the Annual Convention. These amendments may be discussed and amended at the Annual Convention and passed to letter ballot by a two-thirds vote of those present. Two-thirds of the votes cast by letter ballot shall be necessary for their adoption.

A. C. I. STANDARDS

Titles of current Standards, and of Tentative Specifications and Proposed Specifications and Recommended Practice of the Institute and their serial designation are here listed with reference to their publication in the Proceedings of the American Concrete Institute.

Curb and Gutter

Tentative Specifications for Concrete Curb and Concrete Curb and Gutter, S 6-E-27T. Vol. 23, p. 684.

Masonry Units

Standard Specifications for Concrete Building Block and Concrete Building Tile, P 1-A-29. Vol. 23, p. 696—revised—see tentative amendment, Vol. 24, p. 834. Adopted as standard by letter ballot. Note: Vol. 25, p. 605.

Standard Specifications for Concrete Sewer Manhole and Catch Basin Block, P 1-C-29. Vol. 23, p. 694. Adopted as standard by letter ballot. Note: Vol. 25, p. 605.

Standard Specifications and Building Regulations for Concrete Staves, P 4-A-26. Vol. 22, p. 666.

Tentative Specifications for Concrete Brick, P 1-B-26T. Vol. 21, p. 604—revised—see tentative amendment, Vol. 22, p. 667—and Note: Vol. 23, p. 690.

Tentative Recommended Practice for the Manufacture of Concrete Building Block, Building Tile and Brick, P 6-A-25T. Vol. 21, p. 473.

Proposed Recommended Practice for the Manufacture of Concrete Building Block and Tile (progress report of Committee 708 presented for discussion with a view to superseding Tentative Recommended Practice for the Manufacture of Concrete Building Block, Concrete Building Tile and Brick, P 6-A-25T—see above). Vol. 27, p. 1001 (April 1931 JOURNAL).

Tentative Specifications for Cast Stone, P 3-A-29T. Vol. 25, 1929.

Proposed Recommended Practices in the Use of Cast Stone (Report of Committee 704, presented for discussion). Vol. 26, p. 760 (May 1930 JOURNAL).

Pipe and Drain Tile

Standard Specifications for Concrete Drain Tile, P 7-B-25. (As tentatively published Vol. 20, p. 678.)

Tentative Specifications for Reinforced Concrete Sewer Pipe, P 7-C-25T. Vol. 21, p. 584.

Tentative Specifications for Plain Concrete Sewer Pipe, P 7-A-24T. Vol. 20 p. 669.

Tentative Specifications for Reinforced Concrete Culvert Pipe. (Second report. Adopted by the Joint Concrete Culvert Pipe Committee representing American Concrete Institute—Com. J-2—American Association of State Highway Officials; American Concrete Pipe Association; American Railway Engineering Association; American Society for Testing Materials; American Society of Civil Engineers; U. S. Department of Agriculture.) Vol. 25, 1929.

Reinforced Concrete

Tentative Building Regulations for Reinforced Concrete, E 1-A-28T. Vol. 24, p. 791.

Standard Specifications for Concrete and Reinforced Concrete. Vol. 21, p. 329. (Adopted by the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete representing American Concrete Institute—Com. J-1—American Society of Civil Engineers; American Society for Testing Materials; American Railway Engineering Association; Portland Cement Association.)

Tentative Construction Specification for Concrete work on Ordinary Buildings, 502-31T. Vol. 26, p. 1 (November 1929 JOURNAL); discussion Vol. 26, p. 580 (March 1930 JOURNAL); Vol. 27, p. 99 (September 1930 JOURNAL); amended and adopted as tentative specification Vol. 27, p. 1181 (May 1931 JOURNAL).

Tentative Construction Specification for Concrete Work on the Small Job, 506-31T. Vol. 27, p. 65 (September 1930 JOURNAL); discussion, Vol. 27, p. 525 (January 1931 JOURNAL); amended and adopted as tentative specification, Vol. 27, p. 1184 (May 1931 JOURNAL).

Tentative Specification for Supplying, Fabricating and Setting Reinforcing Steel on Ordinary Buildings, 503-31T, with an appendix: "A Steel Setters' Primer." Vol. 26, p. 444 (February 1930 JOURNAL); discussion Vol. 26, p. 910 (June 1930 JOURNAL); adopted as tentative specification Vol. 27, p. 1186 (May 1931 JOURNAL).

Roads

Standard Specifications for One-Course Concrete Pavement for Highways, S 6-A-28. Vol. 20, p. 695.

Standard Specifications for Two-Course Portland Cement Concrete Pavement for Highways, S 6-B-28. (As tentatively published Vol. 20, p. 710.)

Standard Specifications for One-Course Portland Cement Concrete Street Pavement, S 6-C-28. (As tentatively published Vol. 20, p. 716.)

Standard Specifications for Two-Course Portland Cement Concrete Street Pavement, S 6-D-28. (As tentatively published Vol. 20, p. 724.) (Tentative revisions adopted 1928. Vol. 24, p. 852.)

Sidewalks and Floors

Standard Specifications for Portland Cement Concrete Sidewalks, C 2-B-25. Vol. 21, p. 591.

Standard Specifications for Concrete Floors, C 2-A-24. Vol. 20, p. 739.

Proposed Recommended Practice for Heavy Duty (concrete) Floor Finish with Notes on Light Duty Floor Finish
and

Proposed Recommended Practice for Dusted-on (concrete) Floor Finish (embodied in report of Committee 802 presented for discussion) Vol. 26, p. 520 (March 1930 JOURNAL) and discussion Vol. 27, p. 115 (September 1930 JOURNAL).

Surfaces

Standard Recommended Practice for Portland Cement Stucco. C 3-A-23. Vol. 19, p. 471.

Tentative Recommended Practice for Treatment of Exterior Surfaces of Industrial Reinforced Concrete Buildings, C 3-B-25T. Vol. 21, p. 564.

Tentative Specifications, Finish Coat, Portland Cement Stucco, C 3-C-29T. Vol. 25, 1929.

Proposed Recommended Practice for the Use of Pigment Admixtures in Troweled Concrete Surfaces—progress report of Committee 408, presented for discussion, Vol. 27, p. 975 (April 1931 JOURNAL).

Miscellaneous

Standard Methods for the Measurement of Concrete Work, C 5-A-26. Vol. 22, p. 655.

Tentative Purchase Specifications for Concrete Aggregates, E 5-A-29T. Vol. 25, 1929.

Standard Specifications for Monolithic Concrete Sewers and Recommended Rules for Sewer Design, S 3-A-24. Vol. 20, p. 757.
Standard Definitions, G 4-A-23. Vol. 19, p. 319.

Tentative Specification for Ready-Mixed Concrete, 504-31T. Vol. 27, p. 1177 (May 1931 JOURNAL).

Proposed Specification for Concrete Burial Vaults (progress report of Committee 709, presented for discussion) Vol. 27, p. 1251 (June 1931 JOURNAL).

The Institute has done other work in standardization involving specifications and recommended practice now regarded as obsolete or not brought to date, or progress reports which are incomplete and for these reasons not here listed.

MEDALS AND AWARDS

The Wason Medals

Founded by Leonard C. Wason, Boston, past-president, American Concrete Institute.

AWARDS, 1916-1929

For the most meritorious paper presented at each annual convention.

1916 Paper—A. B. MCDANIEL, "Influence of Temperature on the Strength of Concrete."

1917 Paper—CHARLES R. GOW, "History and Present Status of the Concrete Pile Industry."

1918 Paper—DUFF A. ABRAMS, "Effect of Time of Mixing on the Strength and Wear of Concrete."

1919 Paper—W. A. SLATER, "Structural Laboratory Investigations in Reinforced Concrete Made by Concrete Ship Section, Emergency Fleet Corporation."

1920 Paper—W. A. HULL, "Fire Tests of Concrete Columns."

1921 Paper—H. M. WESTERGAARD, "Moments and Stresses in Slabs."

1922 Paper—GEORGE E. BEGGS, "An Accurate Mechanical Solution of Statically Indeterminate Structures by Use of Paper Models and Special Gauges."

1923 Paper—JOHN J. EARLEY, "Building the Fountain of Time."

1924 Two Papers—RICHARD L. HUMPHREY, "Twenty Years of Concrete" and "The Promise of Future Development."

1925 Paper—E. A. DOCKSTADER, "Report of Tests Made to Determine Temperatures in Reinforced-Concrete Chimney Shells."

1926 Paper—A. BURTON COHEN, "Correlated Considerations in the Design and Construction of Concrete Bridges."

1927 Paper—ARTHUR R. LORD, "Notes on Concrete—Wacker Drive, Chicago."

1928 Paper—FRANKLIN R. MCMILLAN, "Concrete Primer."

1929 Paper—L. G. LENHARDT, "The Concrete Lining of Detroit Water Tunnels."

1930 Paper—I. E. BURKS, "Concreting Methods at the Chute a Caron Dam."

AWARDS, FOR RESEARCH, 1929, 1930

S. C. HOLLISTER, for advancing the art of bridge construction in the design, construction and test of a concrete skew arch as reported in his 1928 paper: "The Design and Construction of a Skew Arch."

H. F. GONNERMAN and P. M. WOODWORTH for the work reported in their 1929 paper: "Tests of Retempered Concrete."

The Turner Medal

Founded 1927 by Henry C. Turner, New York, past-president, American Concrete Institute, a gold medal will be awarded not oftener than once a year "for notable achievement in or service to the concrete industry."

AWARDS, 1928, '29 AND '30

Awarded, 1928, to ARTHUR N. TALBOT, for "outstanding contributions to the knowledge of reinforced concrete design and construction."

Awarded, 1929, to WILLIAM K. HATT, for "pioneer work in reinforced concrete research; for a quarter century of devoted, outstanding and continuous service in developing the knowledge of concrete."

Awarded, 1930, to F. E. TURNEAURE, for "distinguished service in formulating sound principles of reinforced concrete design."

MEMBERS

AMERICAN CONCRETE INSTITUTE

An asterisk (*) designates a Supporting Member

Diligent effort is made to keep the official membership card list corrected to date in every detail. This printed list is compiled from that with corrections to July 1, 1931. This register is cross-indexed to include names of individuals designated as representatives of corporation memberships. If errors have crept in please notify us promptly. Names and addresses of new members will be published in the JOURNAL.

—SECRETARY

Abberley, Elbert K., 891 Putnam Ave., Brooklyn, N. Y.
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Aberg, Urho (See Cementproducenternas)
***Aberthaw Company,** Chamber of Commerce Bldg., 80 Federal St., Boston, Mass. (L. C. Wason)
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Ackerman, E. R. (See Louis des Cognets & Co.)
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Akron, University of, Akron, Ohio (E. F. Schaefer)
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Alabama Concrete Pipe Co., 3232 Fayette Ave., Birmingham, Ala.
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Alexander, Chas. A. (See The Alexander Shumway & Utz Co.)
Alexander, E. C. (See Massey Concrete Products Co.)
Alin, A. L., 315 Customhouse, Portland, Ore.
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Allentown Portland Cement Co., Catasauqua, Pa. (R. S. Weaver)
***Alpha Portland Cement Co.,** Easton, Pa. (Louis Anderson, Jr.)
***Alpha Portland Cement Co.,** Easton, Pa. (F. G. McKelvy, Vice-Pres.)
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Althof, L. W., c/o Oregon Short Line R. R., Pocatello, Idaho
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Alvarez, Hnos, Sucr., Calzada Juarez, 35, Queretaro, Qro., Mex.
Alvarez, Salvador (See Alvarez Hnos, Sucr.)
Alves de Lima, Jorge, 51 Rua Libera Badaro, Sao Paulo, Brazil
Alvord, Henry B. (See Northeastern University)

Ambursen Construction Co., Inc., Grand Central Terminal, New York, N. Y. (L. A. Robb)
Amend, Joseph (See St. Louis Duntile Co.)
American Aggregates Corp., Greenville, Ohio (Guy C. Baker)
American Builders Supply Co., 405 Garden St., Louisville, Ky. (Jas. F. McCracken)
American Can Co., 230 Park Ave., New York, N. Y. (C. G. Preis)
American Concrete Marbelite Co., 4727 N. Lamon Ave., Chicago, Ill. (Paul K. Fleming, Vice-Pres. & Gen. Mgr.)
American Concrete Pipe Association, 33 West Grand Ave., Chicago, Ill. (M. W. Loving)
American Hume Concrete Pipe Co., 1139 Griswold St., Detroit, Mich. (F. L. Klingensmith)
American Memorial Co., 1479 Piedmont Ave., Atlanta, Ga. (T. J. Meldrum)
American Reduction Co., 1942 Forbes St., Pittsburgh, Pa. (Jay Moore)
American Sewage Disposal Co., Inc., Elm Court, Stamford, Conn. (F. M. Brown Pres.)
American Sika Corp., 56 West 45th St. New York, N. Y. (Herbert Stoneham)
American System of Reinforcing, Union Trust Bldg., Chicago, Ill. (J. T. Hanley)
American Vault Co., 747 Henry St., Brooklyn, N. Y. (F. H. Van Ness)
American Vibrolithic Corp., 109 8th St., Des Moines, Ia. (H. L. Tillson, Chief Engr.)
Anderson, E. T. (See The Sisalkraft Co.)
*Anderson, Jr., Louis (See Alpha Portland Cement Co.)
Anderson, N. S. (See South Carolina State Highway Dept.)
Anderson, Robt. L. (See Winnetka, Village of)
Anderson, W. G. (See The Dominion Concrete Co., Ltd.)
Ames, Geo. (See Pacific Coast Talc Co.)
Ames, Joe (See Fargo Stone & Sand Co.)
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Amson, A., (See The Foundation Co.,)
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Anderson, Emanuel, American Gas & Electric Co., 30 Church St., New York, N. Y.
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Arlington Concrete Products Co., Arlington Heights, Ill. (Paul C. Taege)
Armin, R. Howard (See Meyer & Holler, Inc.)
Arnold Construction Co., 514 N. Prior Ave., Rm. 16, St. Paul, Minn. (H. W. Small)
Arrow Sand & Gravel Co., The, 904 Hartman Bldg., Columbus, Ohio (S. Stepanian, Vice-Pres. & Gen. Mgr.)
Art Stone Co., Gloversville, New York (A. C. Suits)
Art Stone Co., The, Millers Falls, Mass. (I. L. Bartlett)
Art Stone & Tile Company, 2500 W. Fourth St., Wilmington, Del. (Arthur Pavoni)
Artcrete Products Co., Upper Darby, Pa. (Clarence E Kuemmerle)
Artstone Products, Inc., 52 Vanderbilt Ave., New York, N. Y.
Asano Portland Cement Co., Marunouchi, Tokyo, Japan
Asbestos Shingle Slate & Sheathing Co., Ambler, Pa. (Richard V. Mattison)
Ashland Vault, Inc., 114 E. Seventh St., Ashland, Ohio (H. A. Ledyard, Pres.)
Ashton, Ernest, Allentown, Pa.
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Associated Metal Lath Mfgrs., 205 W. Wacker Drive, Chicago, Ill. (Wharten Clay, Comm.)
Assoc. of Portland Cement Mfgrs., Ltd., Portland House, Tothill St., Westminster, London, S. W.-1, England (H. R. Cox)
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Avril Tru-Batch Concrete, Inc., Este Ave. and B. & O. R. R., Cincinnati, Ohio (A. C. Avril, Pres.)
Avril, A. C. (See Avril Tru-Batch Concrete, Inc.)
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Ayers, L. K. (See Geo. S. Mepham & Co.)
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Badger Concrete Co., 191 Marion St., Oshkosh, Wis. (E. Olsen)

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Bailey, G. S., B. E., Municipality of Botany, Sydney, N. S. W., Australia
Bailey, John M. (See Standard Inspection Co.)
Baingolkar, H. V., No. 2 Assaye Bldg., Colaba, Bombay, India
Baker, Guy C. (See American Aggregates Corp.)
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*Baker, Hugh J. (See Hugh J. Baker & Company)
Bakker, J. A. (See Technische Hoogeschool)
Baker, R. K., Pres. Hampden Paint & Chemical Co., Springfield, Mass.
Baker, Samuel, International Correspondence Schools, Scranton, Pa.
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Balina, M. R., Copernics 2385, Buenos Aires, Argentina
Ballentine, W. L., 83 Jarvis St., Toronto, Ont. Canada
Ballinger Co., The, S. E. Cor. 12th and Chestnut, Philadelphia, Pa. (Jean Paul Rickter)
Ballou, Henry W., 10 Weybosset St., Room 1035 Grosvenor Bldg., Providence, R. I.
Baltimore Bureau of Standards, Municipal Office Bldg., Baltimore, Md. (Conrad Zieget, Jr.)
Ban, S., Technical College, Kyoto Imperial University, Kyoto, Japan
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Baranzelli, G. (See Baranzelli Cast-Stone, Inc.)
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Barrett, E. E. (See Roberts & Schaefer Co.)
Barrett, J. F. (See Barrett & Hilp)
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Bartlett, I. L. (See The Art Stone Co.)
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Baruch, Herbert M. (See Herbert M. Baruch Corp.)
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Baumann, Herman, Companhia Constructora National, S. A., Caixa Postal 1546, Rio de Janeiro, Brazil
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*Bayle, G. F. (See Glens Falls Portland Cement Co.)
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Beattie & Cornell, 33 No. Quarry St., Fall River, Mass.
Beatty, J. A. (See Morrow & Beatty, Ltd.)
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Bedford Construction Co., 333 N. Michigan Ave., Chicago, Ill. (N. H. McKenzie)
Bedford, Max E., c/o Kandos Cement Co. Ltd., 66 Pitt St., Sydney, N. S. W., Australia
Beebe, Inc., H. R., 265 Genesee St., Utica, N. Y. (H. R. Beebe)
Beebe, H. R. (See H. R. Beebe, Inc.)
Beer, F. E. (See Peerless Stone Ltd.)
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Bennett, J. Gardner, Lewis Institute, 1951 Madison St., Chicago, Ill.
Benson Concrete Co., 5103 W. Lake St., Chicago, Ill. (C. H. Johnson)
Benson, Newton D., 36 Burrington St., Providence, R. I.

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Bent, Arthur S. (See Bent Bros.)
Bent Bros., 418 S. Pecan St., Los Angeles, Calif. (Arthur S. Bent)
Bent, Ernest F., Box 1428, Arcade Annex, Los Angeles, Calif.
Bentham, Cecil, 20 Mount St., Manchester England
Berchem, H. C. (See St. Paul Cement Works)
Beretta Engineers, Inc., J. W., 1203 Nat'l. Bank of Commerce Bldg., San Antonio, Texas (J. W. Beretta, Pres.)
Beretta, J. W. (See J. W. Beretta Engineers, Inc.)
Bergen, T. A., Stockholm, 16, Sweden
Berg, Christy L. (See Berg Vault Co.)
Berg, U. T., 136 Liberty St., New York City
Berg Vault Co., 1620 Lucas & Hunt Rd., St. Louis, Mo. (Christy L. Berg)
Bergen Building Block Co., Industrial Ave., Ridgefield Park, N. J. (Howard Brooke)
Bergford, L. M., 556 Builders Exchange, Minneapolis, Minn.
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Bergner, Edward F., 1022 Fillmore Ave., Buffalo, N. Y.
Berks Building Block Co., Northmont-Reading, Pa. (G. M. Muth, Treas. & Mgr.)
Berkshire Gravel Co., Lenoxdale, Mass. (A. I. Newton)
Bernard, Merrill, Crowley, La.
Bernier, Napoleon M. (See California Stucco Products of N. E.)
Berry, H. C., C. E. Dept., University of Pennsylvania, Philadelphia, Pa.
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Besser Manufacturing Co., Alpena, Mich. (J. H. Besser)
Besser, J. H. (See Besser Manufacturing Co.)
Bettendorf Co., The, Bettendorf, Iowa (R. M. Bowling)
Betts, Clifford A., Engr. U. S. Reclamation Serv., Owyhee, Oregon
Bevier, Philip (See National Fireproofing Co.)
Beyer, A. H. (See Columbia University)
Bhaledino, Kambarali, Assistant Engineer, Karachi Municipality, India
Biever, Barton R. (See Pottsville Building Block Co.)
Bigler, H. P. (See Rail Steel Bar Assn.)
Bilde, Tage (See Svenska Cementforeningen)
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Binger, W. D. (See Thompson & Binger)
Bingham, E. H. (See Michigan Concrete Co.)
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Binney & Smith Co., 41 East 42nd St., New York, N. Y. (J. T. Kealy)
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Bird, Millard F., 101 Park Ave., New York, N. Y.
Bird, Harold C. (Dee Duke University Library)
*Bird, Paul P. (See Boston Sand & Gravel Co.)
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Birmingham Public Library, Birmingham, Ala. (Lila May Chapman, Director)
Birmingham Slag Co., Age Herald Bldg., Birmingham, Ala.
Birnie Sand & Gravel Co., No. Wilbraham, Mass. (J. E. Bowker)
Bishop, Harry, c/o P. W. D., Sandakan (via Singapore), British N. Borneo
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Bishop, Howard, Sharon Steel Hoop Co., Sharon, Pa.
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Blackmore, G. C. (See Northwestern States Portland Cement Co.)
Black & Veatch, Mutual Bldg., Kansas City, Mo. (N. T. Veatch, Jr.)
Blackwood, W. H. (See Hud-Cin Building Products, Inc.)
Blair, Wm. R. (See Southwestern P. C. Co.)
Blake, F., "Winsley House" 1, Cotele Nillas, Stoke, Plymouth, Devon, England
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Blanchard & Crandell, 38 5th Ave., Saratoga Springs, N. Y. (A. E. Blanchard)
Blanchard, A. E. (See Blanchard & Crandall)
Blanchard, H. A. (See Buffalo Wash Tray Works)
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Blue Jay Concrete Products Co., 2010 Pennsylvania Ave., Madison, Wisc. (Charles Clare)
Blue Ridge Talc. Co., Inc., Henry, Va. (C. O. Kitson, Secy.-Treas.)
Blyth, Charles E., c/o Chas. Nelson & Co., Stockton Works, Rugby, England
Boettcher, Henry (See Lancaster Concrete Tile Co.)
Bogk, Frederick C. (See Ricketson Mineral Color Works)
Bogue, Robert H., Bureau of Standards, Washington, D. C.
Bolton Pratt Construction Co., The, 426 Marion Bldg., Cleveland, Ohio (K. H. Pratt)
Bond, Guillermo, 11 de Setiembre 1409, Buenos Aires, Argentina
Boomer, Roy E., 1541 W. Boston Blvd., Detroit, Mich.
Borchard, E. K. (See Universal Atlas Cement Co.)
Borut, J., C. E., c/o Public Works Dept., Jerusalem, Palestine
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***Boston Sand & Gravel Co.,** 120 First St., Cambridge, Mass. (Paul P. Bird)
Boston Transit Mixers, Inc., 104 Forsythe St., Boston, Mass. (John T. McMorrow)

Boswell, H. C. (See L. C. Everist, Inc.)
Boulanger, J. L. (See Quebec Dept. of Roads)
Bound Brook Crushed Stone Co., 9 Clinton St., Newark, N. J. (L. Upton)
Bourne, C. L., c/o Geo. Rackle & Sons, Station D, Cleveland, Ohio
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Bowling, R. M. (See The Bettendorf Co.)
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Bradford, L. (See Broken Hill Proprietary Co., Ltd.)
Bradley, C. M. (See Youngstown Sheet Tube Co.)
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Bragger, E. Y., Shawomet, R. I.
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***British Columbia Cement Co., Ltd.,** Victoria, B. C., Canada (Edwin Tomlin, Director, Treas.)
British Columbia Elec. Ry. Co., Ltd., Vancouver, B. C., Canada (E. E. Carpenter)
Britt, Harris (See Sinclair & Grigg)
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Brockway, R. R., 616 6th St. S. E., Minneapolis, Minn.
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Broken Hill Proprietary Co., Ltd., Box 196, Newcastle, N. S. W., Australia (L. Bradford, Mgr.)
Brooke, Howard (See Bergen Building Block Co.)
Brooks, Ernest W., The Rugby Portland Cement Co., Bilton Works, Rugby, England
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Brooks, W. E., Municipal Bldg., Morgantown, W. Va.
Brown, Burtis, 65 Franklin St., Boston, Mass.
Browne, E. F., 1025 Santa Fe Bldg., Dallas, Texas
Brown, F. M. (See American Sewage Disposal Co., Inc.)
Brown, John A. W., 17 Main Street East, Hamilton, Ont.
Brown, J. F., 3426 E. 89th St. Chicago, Ill.
Browne, Nolan (See Penniman Concrete & Material Co.)
Brown, Paul G., Philadelphia Bank Bldg., Philadelphia, Pa.
Brown, Philip P., 1101 Bekins Bldg., Vancouver, B. C., Canada
Brown, Robert (See St. Joseph Cinder Block Co.)
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Brown, S. N. (See Consumers Supply Co.)
Brown & Myers, 1721 Petroleum Bldg., Oklahoma City, Okla.
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Brown, H. Whitemore, Concord, Mass.
Bruce, W. C. (See Barnsdall Tripoli Co.)
Brumbaugh, W. V. (See National Lime Association)
Brundage, Avery, 110 S. Dearborn St., Chicago, Ill.
Bruner, Louis S., 20 So. 36th St., Philadelphia, Pa.
Brunnier, H. J., 612 Sharon Bldg., San Francisco, Cal.
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Bryant, Henry F., 334 Washington St., Brookline, Mass.
Buck, R. C., U. S. National Bank Bldg., Superior, Wis.
*Buente, C. F. (See Concrete Products Co. of America)
Buerkin, Julius A. (See Buerkin & Buerkin)
Buerkin & Buerkin, 201 Broadway, Quincy, Ill. (Julius A. Buerkin)
Buffalo Art Stone Corp., 449 Center St., Lackawanna, N. Y. (E. H. DeVoe)
Buffalo Litholite Company, Box 12, Lackawanna, N. Y. (George E. Hipp)
Buffalo Slag Company, 1070 Ellicott Square, Buffalo, N. Y. (Carlton S. Wicker, Mgr.)
Buffalo Wash Tray Works, Inc., 601 Tonawanda St., Buffalo, N. Y. (H. A. Blanchard)
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Bulger, John, 368 Sherman St., Akron, Ohio
Bullen, Carroll A., 111 W. Washington St., Chicago, Ill.
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Burns, Inc., D. F. & W. G., 9 Park St., Boston, Mass. (Walter G. Burns)
Burns & McDonnell Engineering Co., 406 Interstate Bldg., Kansas City, Mo. (C. S. Timanus)
Burns, Walter G. (See D. F. & W. G. Burns, Inc.)
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Bushnell, E. B. (See Masonite Corp.)
Bushnell, H. L., 1501 Dexter Horton Bldg., Seattle, Wash.
Busse, F. A., 871 Shrine Bldg., Memphis, Tenn.
Buswell, J. M. (See San Joaquin Light & Power Corp.)
Butler Bin Co., 154 Wisconsin Ave., Waukesha, Wis. (Morgan R. Butler, Pres.)
Butler, C. M. (See Marquette Cement Mfg. Co.)
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Butler, Gordon H. (See Polaris Concrete Products Co.)
Butler, Joe B., Assoc. Prof. of Civil Engineering, Mo. School of Mines, Box 547, Rolla, Mo.
Butler, Morgan R. (See Butler Bin Co.)
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***California Portland Cement Co.,** Colton, Calif. (W. C. Hanna, Chief Chemist)
California, State of, Division of Highways, 3435 Serra Way, Sacramento, Calif. (T. E. Stanton)
California Stucco Products of N. E., 411 Walden St., Cambridge, Mass. (Napoleon M. Bernier)
California Stucco Products Co., 1344 University Ave., Rochester, N. Y. (H. D. Kneeland)
California Stucco Products Co. of N. C., 340 Dore St., San Francisco, Calif. (Percy R. Stuart)
Callier, B. C. (See Cement Gun Co., Inc.)
***Calumet Steel Co.,** 33 N. La Salle St., Chicago, Ill. (F. G. Carrel)
Cameron, E. H. (See Jackson & Moreland)
*Cameron, W. P. (See Olympic Portland Cement Co.)
Campbell, J. Bow, c/o Reinforcing Steel Co, P. O. Box 117, Salisbury, Rhodesia, S. Africa.
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Campbell, R. D. (See The General Cement Products Co.)
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Campion, William L., 76 Moraine St., Jamaica Plain, Mass.
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Canada Crushed Stone Corp., Sun Life Bldg., Hamilton, Ont., Canada (C. M. Doolittle)
Canadian Engineering Standards Assn., 178 Queen St., Ottawa, Canada (B. Stuart McKenzie, Secy.)
Canadian National Parks Branch, Dept. of the Interior, Ottawa, Canada. (J. B. Harkin, Commissioner)
Canadian National Railways, Montreal, Que., Canada (W. A. Duff)
Canton Block & Tile Co., Canton, S. Dak. (E. D. Rowe)
Capital Avenue Cement Works, Box 5004, St. Paul, Minn. (A. O. Hovde)
Capouch, M. E., 208 S. La Salle St., Chicago, Ill.
***Carey Co., Philip,** Lockland, Cincinnati, O. (C. V. R. Fullenwider, Mgr. Elastite Dept.)
Carlock, J. B. (See Jones & Laughlin Steel Corp.)
Carlon Construction Co., Oskaloosa, Ia. (Harry F. Carlon)
Carlon, Harry F. (See Carlon Construction Co.)
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Carnwath, James (See Independent Concrete Pipe Co., Ltd.)
Carpenter, C. A. (See Colorado State Agricultural College)
Carpenter, E. E. (See British Columbia Elec. Ry. Co., Ltd.)
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Cavanagh, Jr., W. Curran, Box 1878, Port of Seattle, Seattle, Wash.
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Caye, Webster J. (See Caye Construction Co., Inc.)
Ceglarek, Wallace, Clifford Hotel, Detroit, Mich.

Cement Gun Co., Inc., Allentown, Pa. (B. C. Callier)
Cement Gun Construction Co., 537 So. Dearborn St., Chicago, Ill. (John V. Schaefer, Pres.)
Cement Products Co., P. O. Box 935, Birmingham, Ala. (G. L. Cox, Pres.)
Cementproducenternas, 1 Finland Forening, Kalevagatan 20, Helsingfors, Finland (Urho Aberg)
Cement Stone & Supply Co., 1447 N. Meade, Wichita, Kansas (B. F. Krehbiel, Mgr.)
Central Concrete Mixing Corp., 527 Smith St., Brooklyn, N. Y. (A. Johnson)
Central Texas Iron Works, Drawer L 11, Waco, Texas (L. H. Wood)
Chace, Clyde B., P. O. Box 186, West Palm Beach, Fla.
***Chain Belt Co.,** 736 Park St., Milwaukee, Wis. (B. F. Devine)
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Champion, E. C., c/o Lone Star Cement Co., Nazareth, Pa.
Chandler, J. M. (See Oklahoma Glazed Cement Pipe Co.)
Chapman, Cloyd M., 105 W. 40th St., New York City, N. Y.
Chapman, John J., 702 Westfield, Elizabeth, N. J.
Chapman, Lila May (See Birmingham Public Library)
Chapman & Oxley, 372 Bay St., Toronto, Ont. (J. Morrow Oxley)
Charron, Louis, 3125 Harrison Ave., Detroit, Mich.
Cheney, J. Tyrell (See Kraus Process, Incorporated)
Chhapgar, F. K., 627 Parsi Colony, Dadar, Bombay, India
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Chicago Art Marble Co., 2883-87 Hillock Ave., Chicago, Ill. (M. S. Marcus, Pres.)
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Christensen, E. (See Bundi Portland Cement, Ltd.)
Christensen, E., Mgr. Bundi Portland Cement, Ltd., Lakheri R. S. (B. B. & C. I. Rly.), Rajputana, India
Christiani & Nielsen, Raadhusplads 77 Copenhagen, Denmark
Christiania Portland Cementfabrik, Christiania, Oslo, Norway (Harald Jakhelln)
Christie, H. A., 31 Washington St., East Orange, N. J.
Christoffel Art Stone Co., Station F, No. Milwaukee, Wisc. (John Christoffel)
Christoffel, John (See Christoffel Art Stone Co.)
Christy, C. O. (See H. C. Nutting Co.)
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Cincrete Corporation, 591 Canal St., Milwaukee, Wisc. (L. E. Pitner)
Cinder Block & Material Co., P. O. Box 137, Cedar Rapids, Iowa (H. L. Spaight)
Cinder Block Corporation, Kate Ave. and W. M. R. R., Baltimore, Md. (G. W. Creighton, Gen. Mgr.)
Cinder Concrete Units Corp., 200 Devonshire St., Boston, Mass. (Stephen Kearney)
Cinder Products, Inc., Carthage, Cincinnati, Ohio (W. Keith Clark)
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Clark, Kenneth M., 3645—16th Ave. So., Minneapolis. Minn.
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Clark, W. Keith (See Cinder Products Inc.)
Claussen, Carlos F., Casilla 185, Valparaiso, Chile
Claussen & Claussen, Inc., 1109 Buyers Bldg., Portland, Ore. (W. E. Claussen, Sec.-Treas.)
Claussen, W. E. (See Claussen & Claussen, Inc.)
Clay Products Institute of Calif., 569 Chamber of Commerce, Los Angeles, Calif. (Norman W. Kelch)
Clay, Wharten (See Associated Metal Lath Mfgrs.)
Clement, R. B., Engr., Refiners Oil Co., 315 Miami Sav. Bank Bldg., Dayton, Ohio
Clemmer, H. F., Engineer of Tests & Materials, Engineer Dept., Dist. of Columbia, Washington, D. C.
Clicquennoi, I. M., 204 Wisconsin Ave., Milwaukee, Wis.
Cline, L. A., 1013 North Sycamore St., Los Angeles, Calif.
Clinton Metallic Paint Co., Clinton, N. Y. (John Mott, Vice-Pres.)
Clos, Charles, 227 East 126th St., New York, N. Y.
Clough, G. C., c/o F. T. Ley Co., Inc., 1215 Main St., Springfield, Mass.
Clousing, Louis, 213 City Hall, Minneapolis, Minn.
Clutz, Frank H., 159 Broadway, Gettysburg, Pa.
Coale, George B. (See J. D. Loizeaux Lumber Co.)
Cobb, L. A. (See Billingham & Cobb)
Cobb, W. G., 347 Madison Ave., New York, N. Y.
Coddington, Samuel C. (See Coddington Engineering Corp.)
Coddington Engineering Corp., 290 Third St., Milwaukee, Wis. (Samuel C. Coddington)
Coffman, Herbert, Hercules Cement Corp., 1700 Walnut St., Philadelphia, Pa.
*Coghlan, R. R. (See Marquette Cement Manufacturing Co.)

Cognets & Co., Louis des, 413 E. Main St., Lexington, Ky. (E. R. Ackerman, Secy.-Treas.)
Colburn, D. S., c/o Marquette Cement Mfg. Co., 140 S. Dearborn St., Chicago, Ill.
Colby, Edwin W., 79 Milk St., Boston, Mass.
Collier, Ira L., 6019 34th Ave., N. E., Seattle, Wash.
Collins, H. G., 247 Kenworth Rd., Columbus, Ohio
Collings Co., W. A., 937 7th St., Santa Monica, Calif. (W. A. Collings, Mgr.)
Collings, W. A. (See W. A. Collings Co.)
Colloy Production Company, 4030 Chouteau Ave., St. Louis, Mo. (C. P. Derleth)
Colmar, Daniel, Ramloc Stone Co., Inc., 1055 Broadway, Albany, N. Y.
Colorado State Agricultural College, Road Materials Testing Laboratory, Colo. Experiment Station, Fort Collins, Colo. (C. A. Carpenter)
Colorway, Inc., 3800 S. Racine Ave., Chicago, Ill. (Marshall R. Rust)
Columbus Testing Laboratories Inc., 755 N. High St., Columbus, Ohio (A. B. Braden, Pres.)
Columbia University, Dept. of Civil Engineering, New York, N. Y. (A. H. Beyer, Director of Tests)
Colwell, Curtis C., Assistant County Engineer, Essex County, Hall of Records, Newark, N. J.
Comite Para Propagar el Uso del Cemento Portland, Gante No. 1, Mexico City, Mexico
Commonwealth Portland Cement Co., 4 O'Connell St., Sydney, Australia (Fred J. Beardmore, Secy.)
Conahey, George c/o Johns-Manville Corp., 292 Madison Ave., New York, N. Y.
Concrete Bldg. Units Co., 1129 Garfield St., Oak Park, Ill. (P. F. Huxhold, Secy.)
Concrete Association of India, P. O. Box No. 138, Bombay, India (Alan Moncrieff)
Concrete Block & Products Co., 5740 Martin Ave., Detroit, Mich. (Jos. A. Sattler)
Concrete Constructions Ltd., Broughton House, 47 King St., Sydney, Australia (Thorpe Bray)
Concrete Construction Pty., Ltd., Collins House, 360 Collins St., Melbourne, Australia (L. A. Deegan)
Concrete Engineering Service Co., 230 W. 9th Ave., Columbus, Ohio (H. C. McCall, Ch. Engr.)
Concrete Marble Co., 5300 McKissock Ave., St. Louis, Mo. (G. C. Turner)
Concrete Products Ltd., 5 Banner Block, Regina, Sask.
***Concrete Products Co. of America,** Diamond Bank Building, Pittsburgh, Pa. (C. F. Buente)
Concrete Protection & Color Co., 1312 N. Marston St., Philadelphia, Pa. (John McKay)
Concrete Publishing Co., 400 W. Madison Ave., Chicago, Ill. (Norman M. Stineman)
Concrete Reinforcing Steel Institute, 1207 Tribune Tower, Chicago, Ill. (R. W. Johnson)
Concrete Specialties Co., P. O. Box 330, Camden, N. J. (L. A. Goodwin, Secy.)
***Concrete Steel Co.,** 2 Park Ave., New York, N. Y. (J. F. Havemeyer)
***Concrete Steel Co.,** 2 Park Ave., New York, N. Y. (James F. Curley)
Concrete Steel Engineering Co., 1902 Park Row Bldg., New York, N. Y. (Wm. Mueser)
Concrete Steel Fireproofing Co., 1245 Michigan Theatre Bldg., Detroit, Mich. (S. V. Taylor, Pres.)
Condit, G. H., 501-2 Mutual Home Bldg., Dayton, Ohio
Condit, W. E. (See The Henry J. Spieker Co.)
Condron & Post, 53 Jackson Blvd., W., Chicago, Ill. (C. L. Post)
Cone, R. G., 17 High St., Moorestown, N. J.
Congleton Co., W. T., Box 327, Lexington, Ky. (W. T. Congleton)
Congleton, W. T. (See W. T. Congleton Co.)
Conklin, James Arthur, DeBaun Ave., Ramsey, N. J.
*Conn, Charles F. (See Giant Portland Cement Co.)
Connar, V. N., 516 Frick Bldg., Pittsburgh, Pa.
Connecticut State Highway Dept., Testing Laboratory, Portland, Conn. (F. G. Flood)
Connecticut Quarries Co., Inc., The, 152 Temple St., New Haven, Conn. (A. L. Worthen)
Connell, W. H. (See Pennsylvania State Highway Dept.)
Connors Steel Co., 1007 Empire Bldg., Birmingham, Ala. (Geo. W. Connors)
Connors, Geo. W. (See Connors Steel Co.)
Conrades, Otto S. (See St. Louis Material & Supply Co.)
Consolidated Cement Corp., 111 West Monroe St., Chicago, Ill. (A. W. King)
***Consolidated Concrete Machinery Co.,** Adrian, Mich. (Eugene F. Olsen, Vice-Pres.)
Consolidated Materials Corp., 605 Terminal Bldg., Rochester, N. Y. (Henry F. Marsh)
Consolidated Pipe Co. Ltd., Cor. Decarie Blvd. & C. P. R. Tracks, Cote St. Luc, Montreal, Que., Canada (E. A. Sherrard)
Consumers Supply, 42nd & State Sts., Milwaukee, Wis. (S. N. Brown)
Converse & Co., Inc., J. B., Mobile, Ala.
Conwell & Co., E. L., 2024 Arch St., Philadelphia, Pa. (E. L. Conwell)
Conwell, E. L. (See E. L. Conwell & Co.)
Cooke, C. E. (See Kalman Floor Co.)
Cook, F. W., 63 Eugene St., Buffalo, N. Y.
Cook, W. A., Ready Mix Concrete Ltd., 1401 University Tower Bldg., Montreal, Que.
Coolidge, W. A., Vanderbilt University, Nashville, Tenn.
*Cooper, D. P. (See Lone Star Cement Co.)
Cooper, Gage W., Cooper Supply Co., 6480 E. Eight Mile Rd., Detroit, Mich.
Cooper & Co., Inc., Hugh L., 101 Park Ave., New York, N. Y. (Hugh L. Cooper)
Cooper, Hugh L. (See Hugh L. Cooper & Co., Inc.)
Cooper, Miles K., 619 Henry Bldg., Portland, Oregon
Cooper, Nelson, 103 E. 125th St., New York, N. Y.
Cooper, W. R., 1600 Walnut St., Philadelphia, Pa.
Corben, Horace J., City Hall, Darling St., Cape Town, Cape Province, S. Africa
Core Joint Concrete Pipe Co., Inc., Irvington, N. J. (G. M. Kerr)
Cormier, Ernest, 2039 Rue Mansfield St., Montreal, Canada
Corrado, Anthony, Wainwright St., Providence, R. I.
Corridon, J. B., Clarendon Road, Penn Valley (Marbeth P. O.) Pennsylvania
Cory, Russell G. 50 Church St., New York City, N. Y.
Cothran, F. H., Beauharnois Construction Co., Beauharnois, P. Q., Canada
Cotter, Lt. Comdr. C. H., Navy Yard, Puget Sound, Wash.
Cotterell, Ernest L., Tarmac Limited, Ettingshall, Wolverhampton, England
Cousins, H. E. (See Lockwood Greene Engineers, Inc.)
Cote, A. U., 26 Queen St., E., Toronto, Ont., Canada
Covell Corporation, The, 1600 Walnut St., Philadelphia, Pa.

Cowell Lime & Cement Co., No. 2 Market St., San Francisco, Calif.
Cowin & Co., Ltd., Pacific & Yeoman Sts., Winnipeg, Manitoba (H. B. Henderson)
Cowper Co., The John W., Fidelity Bldg., Buffalo, N. Y. (John W. Cowper)
Cowper, John W. (See John W. Cowper Co.)
Cox, G. L. (See Cement Products Co.)
Cox, H. R. (See Assoc. of Portland Cement Mfgrs. Ltd.)
Cox O. H., Bureau of Standards, Federal Bldg., Denver, Colo.
Coy, Frank A., 2535 Hartrey Ave., Evanston, Ill.
Coyle, David C., 101 Park Av., New York, N. Y.
Crabbs, Austin, Pres., The Cement Products Co., Box 343, Davenport, Ia.
Cramer, M. J., 211 Weick Bldg., Baton Rouge, La.
Crane, Theodore, Weir Hall, Yale University, New Haven, Conn.
Crandell, John S., 308 Engineering Hall, University of Illinois, Urbana, Ill.
Cranford, F. L. (See Frederick L. Cranford, Inc.)
Cranford, Inc., Frederick L., 149 Remsen St., Brooklyn, N. Y. (F. L. Cranford)
Crangle, W. R. (See Metropolitan Concrete Co.)
Creamer, Randall (See Frederick Snare Corp.)
Creighton, G. W. (See Cinder Block Corp.)
Crepps, R. B., 540 Northwestern Ave., West Lafayette, Ind.
Cristofol, J., Cuba No. 52, Havana, Cuba
Crosgrove, G. L. (See Delco Concrete Products Co.)
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Cross, Roy C., 700 Baltimore Ave., Kansas City, Mo.
Crowley, N. D. (See Ready Mix & Supply Corp.)
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Crume Brick Co., The, 511 Keith Bldg., Dayton, Ohio (W. H. Crume)
Crume, W. H. (See Crume Brick Co.)
Cuevas, Jose A., C. E., 7a Calle de Nogal 218, Mexico, D. F., Mexico
Cummings, A. E., 1912 111 West Monroe St., Chicago, Ill
Cummins, Charles A., 20 E. Franklin St., Baltimore, Md.
Cunard Lang Concrete Co., 459 Furnace St., Columbus, Ohio (L. D. Hagerty)
*Curley, James F. (See Concrete Steel Co.)
Curtis, Benjamin J., 1749 W. 96th St., Chicago, Ill.
Curtis, J. P., Preston & Curtis, 44 Rua Buenos Aires, Rio de Janeiro, Brazil
Curtis, L. C., 712 Bankers Reserve Life Bldg., Omaha, Nebraska
Cut Art Stone Co., 101 West 44th St., Savannah, Georgia (M. E. Kleinsteuber)
Cutler, M. H., c/o Stone & Webster Engineering Corp., 49 Federal St., Boston, Mass.
Cutler, Stanley G., 137 S. LaSalle St., Chicago, Ill.
Dahlen, Henry A. (See Deslauriers Column Mould Co., Inc.)
Dahlquist, H. A. (See Perfected Burial Vault Cement Products Co.)
Dailey Contracting Co., H. A., 434 Louderman Bldg., St. Louis, Mo. (Ralph A. Teich)
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Davis, Herbert A., South Washington, Va.
Davis, J. F. (See Robert W. Hunt & Co.)
Davison, J. K. (See J. E. Hayes Engineering Corp.)
Davis, Raymond E., Civil Engrg. Dept., University of California, Berkeley, Calif.
Davis, Watson, 1422 Rhode Island Ave., Washington, D. C.
Davison, R. Glenn, Jamesburg, N. J.
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Dawson, Raymond F. (See University of Texas)
Day, W. P., Room 1502, 405 Montgomery Ave., San Francisco, Calif.
Daymude, C. A. (See Detroit Dept. of Building & Safety Engrg.)
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Deegan, L. A. (See Concrete Construction Pty. Ltd.)
Degling, A. O., 775 Main St., Buffalo, N. Y.
DeGowin, W. R. (See The Detroit Testing Laboratory)
DeGress, F. B. (See The Nailcrete Corp.)
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Dekker, P., Gemeentewerken, Groenewegje 171, The Hague, Holland
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Delaplaine, Henry, 1416 Chestnut St., Philadelphia, Pa.
Delaware State Highway Dept., Dover, Delaware (W. W. Mack, Ch. Engr.)
Delco Concrete Products Co., Marcus Hook, Pa. (G. L. Crosgrove, Mgr.)
DeLeuw & Co., Charles, 111 W. Washington St., Chicago, Ill.
Delin, Major B., Tekniska Byggnadsbyran, Stockholm 3, Sweden
Densmore, LeClear & Robbins, 88 Broad St., Boston, Mass (Henry C. Robbins)
Denton, Arthur P., 785 Market St., San Francisco, Calif.
Denton & Co., 7 E. 42nd St., New York, N. Y. (P. E. Eisenmenger)
Denton, W. Edward, 3809 Alton Place, N. W., Washington, D. C.
Denuel, J. M., Box 111, Milmont Park, Del. Co. Pa.,
DePass, M. B., 926 Pauline St., New Orleans, La.
Derickson, Donald, College of Engineering, Tulane University, New Orleans, La.
Darleth, C. P. (See Colloy Production Co.)
Deroover, G. (See Groupement Prof. des Fabricante)
Deslauriers Column Mould Co., Inc., 101 Tremont St., Boston, Mass. (Henry A. Dahlen)

Des Plaines Concrete Products Co., 916 North Ave., Des Plaines, Ill. (Chas. Gatzke)
Detroit Bureau of Government Research, 51 W. Warren Ave., Detroit, Mich. (Harrington Place)
Detroit Cinder Block & Tile Co., 17201 Newbern Ave., Detroit, Mich.
Detroit Dept. of Building & Safety Engineering, 555 Clinton St., Detroit, Mich. (C. A. Daymude)
Detroit Dept. of Street Railways, Ways & Structures Div., St. Jean & Shoemaker Aves., Detroit, Mich. (P. A. Kerwin)
Detroit Edison Company, 2000 Second Ave., Detroit, Michigan (A. S. Douglass, Construction Engineer)
Detroit Edison Co. Library, 2000 Second Ave., Detroit, Mich.
Detroit Public Library, Woodward & Kirby Aves., Detroit, Mich. (Adam Strohm, Librarian)
Detroit Testing Laboratory, The, 554 Bagley Ave., Detroit, Mich. (W. R. DeGowin)
Detroit, Library, University of, 6 Mile Road & Livernois, Detroit, Mich. (David P. Gilmore)
Deuel, A. W., 545 Fordham Rd., San Mateo, Calif.
Dever, Clare, 5280 Pacific Ave., Detroit, Mich.
Devine, B. F. (See Chain Belt Co.)
Devine, P. S., Pharr, Texas
DeVoe, E. H. (See Buffalo Art Stone Corp.)
Devonald, Ira R., 1 Alan St., West Orange, N. J.
Devos Co., Inc., Wm. H., 3115-29 Auer Ave., Milwaukee, Wisc. (A. W. Devos)
Devos, A. W. (See Wm. H. Devos Co., Inc.)
Dewell, Henry D., 55 New Montgomery St., San Francisco, Calif.
Dewey Portland Cement Co., Suite 101 W. 11th. St., Kansas City, Mo. (F. E. Tyler)
Dewey Portland Cement Co., 315 Union Bank Bldg., Davenport, Ia. (K. P. Ferrell)
Dewson, S. H., 160 Shawnee Ave., Easton, Pa.
Destone Co., The, 1337 Dixwell Ave., Hamden, Conn. (Louis A. Falco)
Dibble, S. Trevor, 49 Winstones Buildings, Queen St., Auckland, N. Z.
Dibert, Grant, Iron City Brick & Stone Co., Stanton & McCandless Aves., Pittsburgh, Pa.
Dicker, W. J. (See Hudson Block & Supply Co., Inc.)
Dickerson, Oliver H., 1909 Jefferson St., Duluth, Minn.
Diehl, Inc., George C., 577 Ellicott Sq., Buffalo, N. Y. (Ray P. Diehl)
Diehl, Ray P. (See George C. Diehl, Inc.)
Dierstein, A. L., Western Brick Co., 216 W. North St., Danville, Ill.
Dillingham, George M., 1400 East 53rd St., Chicago, Ill.
Di Stasio, Joseph, c/o J. Di Stasio & Co., 136 Liberty St., New York, N. Y.
Dittlinger Lime Co., New Braunfels, Texas (E. Eikel)
Diver, M. L., San Antonio, Texas
Dixon, DeForest H., Room 2738, Graybar Bldg., 420 Lexington Ave.,New York, N. Y.
Doane, Louis H., Cor. Pine & Central Aves. North Glenside, Pa.
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Dockstader, Ernest A., 49 Federal St., Boston, Mass.
Dodsworth, E., 79 Rua do Hospicio, Rio de Janeiro, Brazil
Doleman, Herman F., 507 North Charles St., Baltimore, Md.
Dominion Concrete Co. Ltd., The, Kemptville, Ont., Canada (W. G. Anderson, Pres.)
Dominion Concrete Co., Ltd., The, Kemptville, Ont., Canada (W. G. Anderson)
Donaldson & Meier, 1601 Washington Blvd. Bldg., Detroit, Mich. (H. W. Meier)
Dones, Samuel G., 584 Washington St., Dorchester, Mass.
Donohue, Jerry, 608 N. 8th St., Sheboygan, Wisc.
Donovan, John B., 212 Michigan Ave., W., Jackson, Mich.
Doolittle, C. M. (See Canada Crushed Stone Corp.)
Dorr Co., Inc., The, 247 Park Ave., New York City, N. Y. (W. A. Neill)
Doucha, J. C., Mongtomery Ward & Co., Construction Dept., Chicago, Ill.
Douglass, A. S. (See Detroit Edison Co.)
Douglas, M. S., Case School of Applied Science, Cleveland, Ohio
Douthett, C. L. (See Waterloo Concrete Corp.)
Dow Chemical Co., Midland, Mich. (L. C. Stewart)
Dowd, Daniel M., 219 Walnut St., Springfield, Mass.
Downs, Allan B., 61 Elm St., Lebanon, N. H.
Doyle, Frank P., 309 W. 93rd St., New York, N. Y.
Drehmann Paving & Constr. Co., 521-523 Glenwood Avenue, Philadelphia, Pa. (C. E. Drehmann)
Drehmann, C. E. (See Drehmann Paving & Construction Co.)
Dresser, Jr., Theo. P. (See Abbott A. Hanks, Inc.)
Drew Co., Inc., Fred, 2525 Pennsylvania Ave., N. W., Washington, D. C. (Fred Drew, Pres. & Gen. Mgr.)
Drew, Fred (See Fred Drew Co., Inc.)
Dreyer, Walter, 245 Market St., San Francisco, Calif.
Driggers, Clyde, University Station, Gainesville, Fla.
Drill, Max, 889 Broad St., Newark, N. J.
Drysdale, W. F. (See Aerocrete Corp. of Canada, Ltd.)
Dube, Charles, 32 Cherrelyn St., Springfield, Mass.
Duff, C. M., University of Nebraska, Lincoln, Nebr.
Duff, W. A. (See Canadian National Railways)
Dufour, F. O. (See United Engineering & Const. Inc.)
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Duke University Library, Durham, N. C. (Harold C. Bird)
Dunn, C. P. (See Alcoa Power Co., Ltd.)
Dunnells, Clifford G., 1150 Century Bldg., c/o Hunting Davis & Dunnells, Pittsburgh, Pa.
Dunsdon, A. C., Executive Engineer, E. I. Ry., 1 Couper Road, Lucknow, India
Duntile Co. Ltd., 734 Canada Cement Bldg., Montreal, Que., Canada (R. McGillivray)
Duquesne Slag Products Co., Diamond Bank Bldg., Pittsburgh, Pa. (C. L. McKenzie)
Durbin, H. R., 342 Madison Ave., New York, N. Y.
Durham, G. D., c/o Shawinigan Eng. Co., Rapide Blanc, Que., Canada
Durr, C. Warren, 1611 Jefferson Ave., St. Paul, Minn.
Dutton, Earl S., The Tredennick-Billings Co., 10 High St., Boston, Mass.
Dwyer, John R., 221 Seaton Place, N. E., Washington, D. C.
Dyer Construction Co., The, 1924 Broadway, Oakland, Calif. (Kenneth W. Dyer)

Dyer, Kenneth W. (See The Dyer Construction Co.)
Dykeman, Howard E., 3307 Washington Blvd., Cleveland Heights, Cleveland, Ohio
Eagle Chemical Co., 414 So. 3rd St., Milwaukee, Wis. (Charles Schrank, Secy.)
Earley, John J., 2131 G. St., N. W., Washington, D. C.
Earle, Ltd., G. & T., Wilmington, Hull, England (G. F. Earle, Managing Director)
Earle, G. F. (See G. & T. Earle, Ltd.)
East, Frederick A. H., Killick Bldg., Home St., Bombay, India
Eaton, E. C., 3440 Troy Drive, Los Angeles, Calif.
Eberling, C. M., 6109 Franklin Ave., Cleveland, Ohio
Eckert, Ralph T., Makins Sand & Gravel Co., Commerce Exchange Bldg., Oklahoma City, Okla.
Ecole Polytechnique, 4130 St. Denis St., Montreal, Quebec
Economy Concrete Company of Va., Inc., Box 1223, Richmond, Va. (Ernest Wiedemann)
Eddy, W. Paul, Onodaga Litholite Co., 102 N. Beech St., Syracuse, N. Y.
Eddystone Cement Co., 50 Howard St., New York, N. Y. (E. R. Wilner)
Edison Cement Co., New Village, N. J. (George G. Wilsnack)
Edwards, C. E. (See Lamar Pipe & Tile Co.)
Edwards, Harlan H., C. E., 225 E. 11th St., Claremont, Calif.
Edwards, Llewellyn N., U. S. Bureau of Public Roads, Washington, D. C.
Eells, W. C., 205 Wellesley Rd., Syracuse, N. Y.
Egelhoff, R. F., 775 Main St., Buffalo, N. Y.
Eighmie, Borden C., R. F. D. No. 4, Schenectady, N. Y.
Eikel, E. (See Dittlinger Lime Co.)
Eisenmenger, P. E. (See Denton & Co.)
Eitzen, Henry R., North Glenside, Pa.
Eklund, H., Mrg., Hume Pipe Co. (Australia) Ltd., Brisbane, Queensland, Australia
Ekwall, A. (See Royal Swedish Board of Waterfalls)
Eldridge, H. W., New City, Rockland County, New York.
Eldridge, R. V. F., c/o Engineer's Office, 422 Collins St., Melbourne, Victoria, Australia
Electric Tamper & Equipment Co., 433 Railway Exchange Bldg., Chicago, Ill. (M. I. McCarty)
Elford, H., 555 Park St., South, Columbus, Ohio
Elkan, Stanley A., Elkan Stone-Tile Mfg. Co., P. O. Box 715, Macon, Ga.
Elk River Concrete Products Co., Elk River, Minn. (D. W. Longfellow)
Ellis, A. R. (See Pittsburgh Testing Laboratory)
Ellis & Sons, Ltd., John, 16 Pocklingtons Walk, Leicester, England (Basil C. Sharman)
Ellis, Warren L., Raymond Concrete Pile Co., 140 Cedar St., New York, N. Y.
Ellison and Russell, 821 Market St., San Francisco, Calif. (W. H. Ellison)
Ellison, W. H. (See Ellison & Russell)
Elmhurst-Chicago Stone Co., 400 W. 1st St., Elmhurst, Ill. (Martin Hammerschmidt)
Elms, Stephen F., 224 Cortland St., Apt. 22, Detroit, Mich.
Emerson, H. B., c/o Lehigh Portland Cement Co., 111 W. Washington St., Chicago, Ill.
Emerson Co., The Sam W., 1836 Euclid Ave., Cleveland, Ohio (R. E. Laubscher)
Emerson-Norris Co., 163 North Beacon St., Brighton, Boston, Mass. (Frederick A. Norris)
Emme, Frank E., 516 So. Hancock St., Los Angeles, Calif.
Emmons, W. J., 1224 East Engineering Bldg., Ann Arbor, Mich.
Empire Stone Co., Ltd., Thanet House, 231 Strand, London, W. C. 2, England (C. T. J. McDowell)
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England, John, Ocean House, Martin Place, Sydney, N. S. W., Australia
England, J. E. (See Queensland Main Roads Comm.)
Engineer, R. K., 39 Marine Line, Fort, Bombay, India
Ennis, Wm. J., 330 Cornwall St., Hartford, Conn.
Epstein, A., 2001 W. Pershing Road, Chicago, Ill.
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Erickson, Jr., Arioch Wentworth, Greystone House, Swampscott, Mass.
Erickson, Iver, 800 Finance Bldg., Kansas City, Mo.
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Evans, Frank M., 36 Birchwood Rd., Ridgewood, N. J.
Evans, L. T., Apt. 15, 3634 Edwards Road, Cincinnati, Ohio
Evanston, City of, City Hall, Evanston, Ill. (E. M. Goodman)
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Everingham, E. C., The Trussed Concrete Steel Co., Aust. Ltd., York & Barrack Sts., Sydney, N. S. W., Australia
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Eyrick, Jr. George J., 9835 Chenlot Ave., Detroit, Mich.
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Falconer, R. C., Erie Railroad Co., Room 978, 50 Church St., New York, N. Y.
Farey, F. O. (See Robert W. Hunt & Co., Ltd.)
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Farmer, Homer G., 208 S. LaSalle St., Chicago, Ill.
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Farrell, J. I., 283 So. 11th St., Newark, N. J.
Faulkner, H. F., City Engineers Dept., Seattle, Wash.

Fay, Frederick H., 44 School St., Boston, Mass.
Federal American Cement Tile Co., 608 S. Dearborn St., Chicago, Ill. (A. B. Shenk, Engr.)
Federal Cement Tile Co., Hammond, Ind. (J. George Geyer, Gen. Supt.)
Federal Concrete Co., 667 Wyoming Ave., Buffalo, N. Y. (Walter E. Jones, Secy.)
Federici, Albert, Paterson, N. J.
Fegles Construction Company Ltd., Wesley Temple Bldg., Minneapolis, Minn. (D. B. Fegles, Pres.)
Fegles, D. B. (See Fegles Construction Co. Ltd.)
Feher, Francis, 9526 Parkview Ave., Cleveland, Ohio
Fellabaum, C. B. (See The Nat'l Cement Block & Supply Co.)
Feldrappe, M. G., 16801 Hilliard Road, Lakewood, Ohio
Fenkell, Geo. H., Gen. Mgr. Dept. of Water Supply, 735 Randolph St., Detroit, Mich.
Fenton, P. M., c/o Alcoa Power Co., Ltd., Kenogami, Que., Canada
Ferguson, A. Donald, Treas., c/o John W. Ferguson Co., 152 Market St., Paterson, N. J.
Ferguson, J. B. & Co., Hagerstown, Maryland
***Ferguson Co., J. W.,** United Bank Bldg., 152 Market St., Paterson, N. J. John W. Ferguson
Ferguson Lewis R., 1401 Santa Fe Bldg., Dallas, Texas
*Ferguson, L. R. (See Lone Star Cement Co.)
Ferguson, M. W., P. O. Box 433, Roanoke, Va.
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Fernandez, Juan M., Director, Direccion de Bonos de Pavimentacion, Calle 11 No. 1204, La Plata, Argentina, S. A.
Ferrel, K. P. (See Dewey Portland Cement Co.)
Ferrer, Russell R., Mastic, L. I., N. Y.
Ferriday, E. G., Engineer, Truscon Dept., Sime Darby & Co., Ltd., Singapore, Straits Settlements
Ferro Building Products Co., Inc., 369 Lexington Ave., New York, N. Y. (A. Hamburger)
Ferro Concrete Construction Co., 3rd & Elm Sts., Cincinnati, Ohio (H. D. Loring)
***Ferro-Concrete Construction Co.,** 3rd and Elm Sts., Cincinnati, O. (W. P. Anderson)
Ferry Co., Inc., James, Virginia & Mediterranean Aves., Atlantic City, N. J. (James V. Ferry)
Ferry, James V. (See James Ferry Co., Inc.)
Fertell, Arthur, Raymond Concrete Pile Co., 140 Cedar St., New York, N. Y.
Feuereisen, Eduardo H., Casilla 125 Vina del Mar, Chile, S. America
Filho, Eng. Julio Miguel Freitas, Rua Abilio Soares 44, Sao Paulo, Brazil
Finishing Lime Assoc. of Ohio, The, 508-9 Home Bank Bldg., Toledo, Ohio (L. E. Johnson)
Fink, John C., 27 Addison Ave., Rutherford, N. J.
Finlayson, Prof. J. N. (See University of Manitoba Library)
Finlay, L. G., 140 Cedar St., New York, N. Y.
Fischer, L. J., 250 Park Ave., New York City, N. Y.
Fishburn, Cyrus C., c/o Rm. 151, Industrial Bldg., Bureau Standards, Washington, D. C.
Fisher, Frank F., (See Fisher-DeVore Const. Co.)
Fisher, G. A. (See Yosemite Portland Cement Corp.)
***Fiske-Carter Construction Co.,** 11 Foster St., Worcester, Mass. (Burton C. Fiske)
Fisher-DeVore Const. Co., The, Box 36, Evanston Sta., Evanston, Ohio (Frank F. Fisher)
*Fiske, Burton C. (See Fiske-Carter Construction Co.)
Fitch, T. A. (See Los Angeles City Engineering Dept.)
Fitz Gerald, C. C., La Metropolitana 314, Havana, Cuba
Flanagan, Charles A., 406 Lyceum Ave., Roxborough, Philadelphia, Pa.
Fleming, Paul K. (See American Concrete Marbelite Company,)
Flesheim, S. W. (See The Master Builders Co.)
Fletcher, B. J., Wear-Ever Building, New Kensington, Pa.
Fletcher-Thompson, Inc., P. O. Box 85, Bridgeport, Conn. (Edward A. Lambert)
Flight, Oscar, Carpenter St., Bendigo, Victoria, Australia
Flood, F. G. (See Connecticut State Highway Dept.)
Florida Concrete Products Assn., c/o The Halifax Concrete Products Co., Daytona Beach, Fla. (Walter Snead, Secy.)
Florida Portland Cement Co., P. O. Box 1075, Tampa, Fla. (Cyrus N. Wells)
Florida State Road Dept., Testing Division, Gainesville, Fla. (H. C. Weathers)
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Fonseca, Humberto da, Escriptorio Technico da 52, Divisao, Sorocabana Ry., Sao Paulo, Brazil, S. A.
Foote Co., Inc., The, Nunda, N. Y. (Chas. A. Lynch)
***Ford, Beacon & Davis, Inc.,** Birmingham, Ala. (Geo. I. Rhodes, Vice-Pres.)
Forest City Testing Laboratory, The, 6545 Carnegie Ave., Cleveland, Ohio (C. H. Lovejoy)
Formell, Victor M., San Carlos baja 51, Santiago de Cuba
Formigli Architectural Stone Co., Real Estate Trust Bldg., Philadelphia, Pa. (Paul Formigli, Sec.)
Formigli, Paul (See Formigli Architectural Stone Co.)
Forrest, V. E., Kennedy & L St., N. E., Minneapolis, Minn.
Forssell, Carl, Kommendorsgt 23, Stockholm, Sweden
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Foster, Harry L. (See The Foster Construction Co.)
Foster, W. A., University of Illinois, Urbana, Ill.
Foster, Winslow H., 9238 Pleasant Ave., Chicago, Ill.
Fougner, Hermann, 103 Park Ave., New York City
Fouilhoux, J. Andre, 40 W. 40th St., New York, N. Y. (Raymond M Hood)

Foundation Co., The, 120 Liberty St., New York, N. Y. (A. Amson)
Foundation Co. of Canada Ltd., The, 746 Sherbrooke St. West, Montreal, Que., Canada (V. G. Younghusband)
Fowden, Wm (See South Dakota Cement Plant)
Fowle, R. E. (See Granite Rock Co.)
Franc, Joseph, Bratislava, Ruzova 12, Czechoslovakia
Francisco, F. Le Roy, 511 Fifth Ave., New York, N. Y.
Franki, Pieux, 196 Due Gretry, Liege, Belgium
Frankland, F. H., 200 Madison Ave., New York, N. Y.
Franklin, Jack, 7071 Plankinton Bldg., Milwaukee, Wisc.
Franklin Limestone Co., Nashville, Tenn. (A. B. Rodes)
***Franklin Steel Works,** Franklin, Pa. (E. E. Hughes, Vice-Pres.)
Franz, Herbert J., 30 Homes Ave., Dorchester, Mass.
Fraser, Andrew, 622-24 American National Ins. Bldg., Galveston, Texas
Fraser, Alexander, Department of Roads, Parliament Bldg., Quebec, Canada
Frauenfelder, Herman, 4600 Chippewa St., St. Louis, Mo.
Frazier, W. H. (See Pyramid Company)
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Freeman, G. L. (See Moran & Proctor)
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Friel, G. M. (See Anchor Concrete Machinery Co.)
Friis, Kristen, Lokkevei 9, Oslo, Norway
Friis, Nelson A. (See Architectural Stone Co.)
Fritz Co., C. B., 138 N. Francis St., Madison, Wis. (N. J. Schmitz)
Froehling & Robertson, Richmond, Va. (T. B. Hartless)
Frolich, A. K., Louisville, Nebr.
Froemming Brothers Inc., 4384 N. Green Bay Ave., Milwaukee, Wis. (B. A. Froemming)
Froemming, B. A. (See Froemming Brothers Inc.)
Frosch, A. E., Eastern Ohio Sand & Supply Co., East Liverpool, Ohio
Frost, Chamberlain & Edwards, Slater Bldg., Woscester, Mass.
Frost, Hermann, A/S Jernbeton Trondhjem, Trondhjem, Norway.
Frost, Rikard V. (See Svenska Betongforeningen)
Fruchtbaum, J., c/o Reecon Inc., 37 Crestwood Ave., Buffalo, N. Y.
Fugate, G. L., Assitant City Engineer, Dept. of Public Works, Houston, Tex.
Fulcher, Edmund, 404 22nd St., Brandon, Manitoba, Can.
Fullenwider, C. V. R. See The Philip Carey Company)
Fuller Co., Fuller Bldg., Catasauqua, Pa. (P. F. Stauffer, Sales Mgr.)
Fuller, Fred D. (See Builders Concrete Stone Co.)
Fuller, Geo. W. (See Fuller & McClintock)
Fuller, Samuel Leslie (See John F. Casey Co.)
Fullerton, Robert (See Made-Rite Products Co.)
Fuller & McClintock, 170 Broadway, New York City, N. Y. (Geo. W. Fuller)
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Gabriel Steel Co., 13700 Sherwood Ave., Detroit, Mich. (W. F. Zabriskie)
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Galien Concrete Tile Co., Galien, Mich. (C. A. Roberts, Sec. & Treas.)
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Gallagher, John J. (See Goodwin-Gallagher Sand & Gravel Corp.)
Gallagher, John P., 16 Hawthorne St., Watertown, Mass.
Gamboa & Domingo, Gran Via No. 13, Bilbao, Spain
Gannett, J. K., The Austin Co., 120 Broadway, New York City
Gardiner, Lion (See Lakewood Engineering Co.)
Gardner, Franc E., 3123 Bloomingdale Rd., Chicago, Ill.
Gardner, Guy O., Ash Grove Lime & Portland Cement Co., Chanute, Kans.
Gardner, W. McG., 313 Grosvenor Ave., Westmount, P. Q., Canada
Gardiner, W. H. (See Winston Bros. Co.,)
Cincero-Garita, Ricardo, C. E., Calle de Versovia 58, Mexico City, Mexico
Garnsey, Arnold Hugh, City Engineer, Town Hall, Sydney, Australia
Garrett, W. S., c/o Barclays Bank, Circus Place, London Wall, London, England
Garties, George, 2400 Gilbert Ave., Cincinnati, O.
Gaskill, P. D. (See Whitehall Cement Mfg. Co.)
Gaston, H. F., Pennsylvania Brick & Tile Co. Inc., Westmoreland Wharves, Philadelphia, Pa.
Gatzke, Chas. (See Des Plaines Concrete Products Co.)
Gauthier, P. G., c/o Beauharnois Construction Co., Box 50, Beauharnois, Que., Canada
Gautier, R. C., 103 Park Ave., New York, N. Y.
Gazaleh, Edouard, 42 Rue Sultan Abdel Aziz, Mazarita, Alexandrie, Egypt
Gazder, Mahamed Hashim, Lloyd Barrage & Canals Construction, Mirpurkhas, Sind, India
*Gay, George R., (See Santa Cruz Portland Cement Co.)
General Cement Products Co., Suite 930, Grant Bldg., Pittsburgh, Pa. (R. D. Campbell)
General Material Company, 605 Buder Bldg., St. Louis, Mo. (H. F. Thomson)
Gentry, J. W., Tenn. Dept. of Hwys. & Public Works, Lebanon, Tenn.
Geupel, Carl M., 1017 Hume Mansur Bldg., Indianapolis, Ind.
Geyer, J. George (See Federal Cement Tile Co.)
***Giant Portland Cement Co.,** Pennsylvania Bldg., Philadelphia, Pa. (Chas. F. Conn)

Gibbs, F. H., c/o Municipal Supplies Ltd., 1192 University St., Montreal, Que., Canada
Gibson, Jr., Chas. H., Tuskegee Inst., Ala.
Gibson, W. Herbert, Harrison Bldg., Philadelphia, Pa.
Giesecke, F. F. (See Texas Engineering Experiment Sta.)
Giesecke & Harris, 205 W. 7th St., Austin, Tex. (Munsey Wilson)
Gilbert, W. T. (See C. W. Blakeslee & Sons, Inc.)
Giles, Roy T., Atlas Lumnite Cement Co., 135 E. 42nd St., New York, N. Y.
Gilkey, Herbert J., 205 Engineering Bldg., No. 1, University of Colorado, Boulder, Colo.
Gill, Grayson, 307 Construction Industries Bldg., Dallas, Texas
Gillette, Harold S., 1913 Fort Worth National Bank Bldg., Fort Worth, Texas
Gillewicz, Zdzislaw, Nowogrodzka 25, Warszawa, Poland
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Gillon, Frank, 150 Davenport Ave., New Haven, Conn.
Gillon, Gerald Norton, 12 Manilla St., Dannevirki, New Zealand
Gilman, Charles, 50 Church St., New York, N. Y.
Gilmore, David P. (See University of Detroit Library)
Ginder, J. W., 439 Treasury Bldg., Washington, D. C.
Ginsberg, Frank I., H. O. Penn Co., 140th St. & E. River, New York,. N. Y.
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Glassett, Alfred T., Barney Ahlers Const. Corp., 110 W. 40th St., New York, N. Y.
Gleason, Kate, Beaufort, Sea Islands, S. C.
Gleason, W. A., Box 1878, Seattle, Wash.
Glen, Michael G., Division of Highways, San Bernardino, Calif.
***Glens Falls Portland Cement Co.,** Glens Falls, N. Y. (Geo. F. Bayle, Jr., Vice-Pres.)
***Glens Falls Portland Cement Co.,** 205 Lower Warren St., Glens Falls, N. Y. (G. F. Bayle)
Glenn, B., Oregon State College, Corvallis, Oregon
Glover Company Inc., Geo. J., Whitney-Central Bldg., New Orleans, La.
Goddard, Calvin S., 69 Woodmont St., Portland, Me.
Goetz, John A., Mattoon, Ill.
Goldbeck, A. T. (See National Crushed Stone Assn.)
Golden Bay Cement Co., Ltd., The, P. O. Box 486, Wellington, New Zealand
Goldsmith Metal Lath Co., The, Chickering Ave. & B. & O., Cincinnati, Ohio (Louis I. Zagoren, Ch. Engr.)
Gomez-Perez, Francisco, Alfonso Herrera 56, Mexico City, Mexico
Gonnerman, H. F., Portland Cement Association Research Laboratory, 33 West Grand Ave., Chicago, Ill.
Gonzalez, Adriano, P. O. Box 1438, San Juan, Puerto Rico
Gonzalez, Carl E., P. O. Box 3591, Santurce, Porto Rico
Goode, R. A., The Building & Gen. Trading Co., Moshi, Tanganyika, E. Africa
Dooding, O. E. (See Standard Gravel Co.)
Goodman, E. M. (See City of Evanston)
Goodman, Hal W., Box 347, Portsmouth Ohio
***Goodwin-Gallagher Sand & Gravel Corp.,** 21 East 40th St., New York, N. Y. (John J. Gallagher)
Goodwin, L. A. (See Concrete Specialties Co.)
Gorman, Walter J. (See Sureseal Manufacturing Co.)
Gorsuch, V. D., Bessemer Cement Corp., Youngstown, Ohio
Goss, R. G., 13 Rainsford Road, Toronto 8, Ont., Canada
Gottlieb, R. D., 2000 Colquitt St., Houston, Tex.
Gottschalk, L. F., Columbus, Nebraska
Gottschalk, Otto, Buenos Aires, Arg., U. S. address 137 Smith St., Perth Amboy, N. J.
Gould Contracting Co., P. O. Box 56, 723 Argyle Ave., Nashville, Tenn. (C. B. Wilson)
Gould, Harley J., c/o Ferro-Concrete Constr. Co., 3rd and Elm Streets, Cincinnati, Ohio
Gow, Charles R., 38 Charles River Road, Cambridge, Mass.
Gowdy, Roy C., 457 Railway Exchange Bldg., Denver, Colo.
Graf, Otto, Spittler-strasse 18c, Stuttgart, Germany
Gram, Lewis M., 227 West Engineering Bldg. University of Michigan, Ann Arbor, Mich.
Granite Rock Co., Watsonville, Calif. (R. E. Fowle)
Grant, J. R., 1202 Bekins Bldg., Vancouver, B. C., Canada
Grasselli Chemical Co. Inc., The, Guardian Bldg., Cleveland, Ohio (R. F. Remler)
Grassi & Co., P., 1945 San Bruno Ave., San Francisco, Calif. (P. Grassi)
Grassi, P. (See P. Grassi & Co.)
Gravell, Inc., Wm. H., N. E. Cor. 15th & Locust St., Philadelphia, Pa. (Wm. H. Gravell, Pres.)
Gravell, Wm. H., (See Wm. H. Gravell Inc.)
Gray Concrete Co., Thomasville, N. C. (F. B. Gray, Secy. & Treas.)
Gray Construction Co., John V., 330 Bay St., Toronto, 2, Ont., Canada (F. S. Milligan)
Gray, F. B. (See Gray Concrete Co.)
Gray, Howard A., 862 Park Sq. Bldg, Boston, Mass.
Gray, T. Campbell, The Concrete Association of India, 4/35, Khaleeli Mansions, Mount Rd., Madras, India
Gray, William J., P. O. Box 292, Springfield, Mo.
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Greater Winnipeg Water District, Civic Offices, Winnipeg, Manitoba. (W. M. Scott, Chairman of Commissioners)
Green, Howard R., Bever Bldg., Cedar Rapids, Ia.
Greenfield, Inc., Arthur, 1 Union Sq., West, New York, N. Y. (Arthur Greenfield)
Greenfield, Arthur (See Arthur Greenfield, Inc.)
Greenfield, Frank L. (See Gulick-Henderson Co.)
Greenman, Russell S., 10 Steuben St., Albany, N. Y.
Gregson, Harry St. John-Russell-de-Lys-, c/o Sir J. Jackson Ltd., H. M. Naval Base, Singapore, Straits Settlements
Greiner, J. E., Lexington Bldg., Baltimore, Md.
Grid Flat Slab Corp., 761 Dudley St., Boston, Mass. (Edwin F. Allbright)
Griffith, Norman (See Nonporite Pty. Ltd.)
Grisi, Adolfo P., Calle 5 No. 1380, LaPlata, Argentina
Grone, Edwin Arthur, 3044 You St., Lincoln, Nebr.

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Grundt, Odd, Torvet 9, Oslo, Norway
Grutsch, Frank J. (See St. Louis Concrete Products Mfg. Co.)
Guaranteed Concrete Co., 210 Builders Exchange, St. Paul, Minn. (A. R. Shiely, V. P.)
Guarantee Construction Co., 17 Battery Place, New York City, N. Y. (Edward Burns, Vice-Pres.)
Guarello, Angel (See Inspeccion de Caminas)
Guest, Walter C., C. M. Guest & Son, Anderson, S. C.
Gulf Concrete Pipe Co., P. O. Box 1765, Houston, Texas (H. E. Johnsen, Vice-Pres.)
Gulick-Henderson Co., 19 West 44th St., New York City (Frank L. Greenfield)
Gundersen, August (See A/S Hoyer-Ellefsen)
Gunn, Charles M., Gunn, Carle & Co., Ltd., 444 Market St., San Francisco, Calif.
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Hackett, Thos. P., The Cincinnati Cement Products Co., 2022 Dana Ave., Cincinnati, Ohio
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Haertlein, Albert, Harvard Engineering School, Pierce Hall, Cambridge, Mass.
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Hagerty, L. D. (See Cunard Lang Concrete Co.)
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Hall Construction Co., 500 Board of Trade Bldg., Indianapolis, Ind.
Hallahan, John P., 3116 Market St., Philadelphia, Pa.
Halliburton Oil Well Cementing Co., Duncan, Oklahoma (Hayden Roberts, Chemist)
Halloran, Lt. P. J., (Cec) U. S. N., 200 25th St., Jackson Heights, L. I., N. Y.
Hambly, Percy Noel, Industrial Constrs., Ltd., 54 Victoria St., London, S. W. I., England
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Hamel, Edouard (City of Quebec)
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Hamilton Gravel Co., The, North Third St., Hamilton, Ohio (W. P. Watson, Sec.-Treas.)
Hamilton & Weeber, 624 Grand Rapids Nat'l Bank Bldg., Grand Rapids, Mich. (E. R. Weeber)
*Hamlin, H. P. (See Raymond Concrete Pile Co.)
Hammerschmidt, Martin (See Elmhurst-Chicago Stone Co.)
Hammill, Harold B., 42 Portsmouth Road, Piedmont, Oakland, Calif.
Hammond, Inc., Ross B., 1312 Public Service Bldg., Portland, Ore. (Ross B. Hammond)
Hammond, Ross B. (See Ross B. Hammond, Inc.)
Hand, Mrs. Elsie D. (See Oklahoma A. & M. College Library)
Hand, George T., Chief Engr., Lehigh Valley Railroad, 143 Liberty St., New York, N. Y.
Hands, Stanley M., 218 Johnson Co., Bank Bldg., Iowa City, Ia.
Hanks, Inc., Abbott A., 624 Sacramento St., San Francisco, Calif. (Theo. P. Dresser, Jr., Chief Engr.)
Hanley, Hunter W. (See Euphrat-Hanley)
Hanley, J. T. (See American System of Reinforcing)
Hanna, Frank W., 512 16th St., Oakland, Calif.
Hanna, H. B., 313 Elias Ave., Peterboro, Ont., Canada
Hanna, W. C. (See California Portland Cement Co.)
Hannaford, H. Eldridge, 1024 Dixie Terminal Bldg., Cincinnati, Ohio
Hannaford, W. S. P. (See W. J. Hynes, Ltd.)
Hannan, Frank J. (See Richard Taylor & Co.)
Hanneman Bros., 7841 South St., Detroit, Mich.
Hannock, Charles F., County Engineer's Office, Miami, Fla.
Hansard, Orren H., 174 Third Ave., N., Nashville, Tenn.
Hansen, Ralph, Central Y. M. C. A., Cleveland, Ohio
Harboe, Prof. Ed., Consulting Engr., Trondhjem, Norway
Harboe, Helge, Scott & Urner, Caixa Postal, 1863, Rio de Janeiro, Brazil
Harber, G. Peyton, Albany, Oregon
Hardesty, J. M. (See Bell Telephone Laboratories)
Harding, Carroll R., 65 Market St., San Francisco, Calif.
Harding, E. C., Ferro-Concrete Construction Co., 3rd & Elm Sts., Cincinnati, Ohio
Hardy, A. W., 303 N. Washington, Magnolia, Ark.
Hargen, Stanley, 133 Rutland Road, Brooklyn, N. Y.
Haring, Ellis E., 1744 Bellaire St., Denver, Colo.
Harkness, E. B. (See Illinois Steel Co.)
Harkness, London & Hertzberg, 17 Queen St., E., Toronto 2, Ont., Canada
Harkin, J. B. (See Canadian National Parks Branch)
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Harris, Wallace R., Knickerbocker Hotel, Milwaukee, Wis.
Harrison, Allrich S. (See Minwax Company, Inc.)
Harrison, Dr. H. C. (See Westinghouse Electric & Mfg. Co.)
Harrison, Merritt, Harrison & Turnock, 1001 Architects Bldg., Indianapolis, Ind.
Hart, W. E., 33 W. Grand, Ave., Chicago, Ill.
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Harter, B. D. (See Harter-Marblecrete Stone Co.)
Hartford, City of, Dept. of Buildings, 550 Main St., Hartford, Conn. (Philip A. Mason, Bldg. Supervisor)

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Hatch, Margaret (See Standard Oil Co. Library)
*Hatch, Wm. M. (See Peerless Portland Cement Co.)
Hatt, William K., Purdue University, Lafayette, Ind.
*Haubert, E. P. (See Lawrence Portland Cement Co.)
Haupt, Chas. E. (See Standard Oil Development Co.)
Hausman Steel Co., The, P. O. Box 416, Toledo, Ohio
*Havemeyer, J. F. (See Concrete Steel Co.)
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Hay, Alan K. (See Ottawa Suburban Roads Commission)
Hay, William Wren, c/o Cox & Jordan, 40 Wall St., New York, N. Y.
Hayden, J. M., Calif. Highway Commission, San Simeon, Calif.
Hayden, R., 420 Lexington Ave., New York N. Y.
Haydite Co., The, 403 Mutual Bldg., Kansas City, Mo. (Dan F. Servey)
Haydock, Winters (See Department of City Transit, City of Pittsburgh)
Hayes Engineering Corp., J. E., 49 Taku Road, Tientsin, China (J. K. Davison)
Hayes, Walter W., c/o Turner Constr. Co., 90 Dover Road, Wellesley, Mass.
Hayley, Harry, Hurdman Road, Ottawa, Canada
Hayner, J. L., 30 Parkview Ave., Pittsburgh, Pa.
Haynes, S. B., 511 Myrick Bldg., Lubbock, Texas
Headman, Sasha, Tucson Gas, Electric Light & Power Co., Tucson, Ariz.
Healy, Ralph F. (See Igoe Brothers)
Hebblewhite, W. R. (See Standards Association of Australia)
Hebold, Denis O., 217 West Sparks St., Philadelphia, Pa.
Hedderich, H. F., c/o Westinghouse Elec. & Mfg. Co., 3850 Bingham Ave., St. Louis, Mo.
Heidenreich, E. Lee, 618 Kansas City Life Bldg., Kansas City, Mo.
Heidenreich, Jr., E. Lee, 252 Water St., Newburgh, N. Y.
Heilbronner, L. C., Caixa Postal 2947, Sao Paulo, Brazil
Henderson, H. B. (See Corwin & Co., Ltd.)
Hendrickx, Jean, 125 Quai de Valmy, Paris, Xeme, France
Henny, D. C., Spalding Bldg., Portland, Oregon
Hepburn, William, 2 Primrose St., White Plains, N. Y.
***Hercules Cement Corp.,** Nazareth, Pa.
Hernandez, Inc., Clinton N., 208-210 McLean Ave., Yonkers, N. Y. (Clinton N. Hernandez)
Hernandez, Clinton N. (See Clinton N. Hernandez, Inc.)
Herron, Co., The James H., 1360 W. Third St., Cleveland, Ohio (James H. Herron)
Herron, James H. (See The James H. Herron Co.)
Hersey Co., Ltd., Milton, 980 St. Antoine St., Montreal, Que., Canada (M. F. MacNaughton)
Hersum, LeRoy M., 6 Beacon St., Boston, Mass.
Hertz, A. L., Box 38, Balbao, Canal Zone
Hertz, H. P., Routledge & Hertz, Archts. & Engrs., 204-5 Ex. Nat'l Bank Bldg., Hutchinson, Kan.
Hewes, George C., 403 Chestnut St., Haddonfield, N. J.
Hews, W. P. (See Yakima Cement Products Co.)
Hibbs, Manton E., Upsal Gardens, Germantown, Philadelphia, Pa.
Hickerson, T. F., Chapel Hill, N. C.
Hidalgo, Rafael A., Casilla 979, Panama, Republic de Panama
Higgins, N. B. (See Pennsylvania Water & Power Co.)
Hilker Supply Co., 16th & State St., Granite City, Illinois (E. W. Hilker, Pres.)
Hilker, E. W. (See Hilker Supply Co.)
Hill, Louis C. (See Quinton Code & Hill)
Hill & Taylor, A. M. P. Buildings, Cairns, North Queensland, Australia (A. J. Taylor)
Hill, W. N., 519 Loucko Ave., Peoria, Ill.
Hilts, H. E., 123 So. Broad Street, Philadelphia, Pa.
*Hilts, H. E. (See Lone Star Cement Co.)
Hinchman, T. H., Smith, Hinchman & Grylls, Marquette Bldg., Detroit, Mich.
Hinder, R. B., Kandos Cement Co., Ltd., 66 Pitt St., Sydney, N. S. W., Australia
Hindman, W. S., 172 E. North Broadway, Columbus, Ohio
Hipp, George E. (See Buffalo Litholite Co.)
Hipwell, Howard S., 1425 City Hall Annex, Philadelphia, Pa.
Hirschberg, Walter P., 218 Stephenson Bldg., Milwaukee, Wisc.
*Hirsh, A. M. (See Lock Joint Pipe Co.)
Hirth Concrete Breaking Co., 3851 No. Hubbard St., Milwaukee, Wis. (G. W. Hirth)
Hirth, G. W. (See Hirth Concrete Breaking Co.)
Hislop, W. A., Box 128, Leeton, N. S. W., Australia
Hitchings, A., 3520 Harford St., Seattle, Wash.
Hodge, Ernest R., Education Office, Wanganui, N. Z.
Hodges Construction Co., The, Chamber of Commerce Bldg., Cincinnati, Ohio (J. E. Hodges)
Hodges, J. E. (See The Hodges Construction Co.)
Hoeffer & Co., 308 W. Washington St., Chicago, Ill. (Alexander C. Warren)
Hoerr, Philipp J., 1104 Frye Ave., Peoria, Ill.
Hoffman, A. E., Gen. Mgr., Clinton Motors Corp., Reading, Pa.
Hoffman Co., F., 901 Wood St., Wilkinsburg, Pa. (Wm. F. Hoffman)
Hoffman, L. R., 1143 Buckingham Rd., Grosse Pointe Park, Mich.
Hoffman, R. B., 14 Del Monte Ave., Monterey, Calif.
Hoffman, Wm. F. (See F. Hoffman Co.)
Hoke, Arnold, Cementon, Pa.
Holabird & Root, 333 N. Michigan Ave., Chicago, Ill. (E. A. Renwick)
Holdsworth, Harry (See Holdsworth Patents Inc.)
Holdsworth Patents Inc., 250 W. 57th St., New York, N. Y. (Harry Holdsworth)
Holleran, L. G. (See Westchester County Park Commission)
Hollister, S. C., Dept. of Structural Engineering, Purdue University, Lafayette, Ind.

Hollywood Concrete Pipe Co., P. O. Box 2057, DeSoto Station, Memphis, Tenn. (O. H. Miller, Pres.)
Hollywood Building Block Co., No. Plymouth St., Allentown, Pa. (Paul R. Klotz)
Holm, W. M., Springer Transfer Co., Inc., P. O. Box 572, Albuquerque, New Mexico
Holmes, Ltd., A. R., 11 Castle Frank Cres., Toronto, Canada (A. R. Holmes, Pres.)
Holmes, A. R. (See A. R. Holmes, Ltd.)
Holmes, Francis, 208-12 Tranaki St., Wellington, New Zealand
Holst, Helge (See Teknisk Bibliotek)
Holter, A., Brevik, Norway
Holton, Jr., Philip J., 389 Charles St., Providence, R. I.
Holz, Herman A., 167 East 33rd St., New York, N. Y.
Holtz & Co., Inc., R. B., Grand Central Terminal, New York, N. Y. (R. B. Holtz)
Holtz, R. B. (See R. B. Holtz & Co., Inc.)
Honig, B. A. (See Vigorose Cement Industrie, N. V.)
Hooks, James H., Alberene Stone Co., 153 West 23rd St., New York, N. Y.
Hool, George A., c/o The Shelton, New York, N. Y.
Hopton, H. V., 306 Cowan St., Nashville, Tenn.
Horn, A. E., Horn Building, Long Island City, N. Y.
*Horner, A. W. (See Kosmos Portland Cement Co.)
Horner, J. M., 250 Conway St., Carlisle, Pa.
Horner & Wyatt, 470 Board of Trade Bldg., Kansas City, Mo. (Roy M. Wyatt)
Horner, Wesley W., 300 City Hall, St. Louis, Mo.
Horst Co., Henry W., 1505 Race St., Philadelphia, Pa. (A. E. Horst)
Horst, A. E. (See Henry W. Horst Company)
Hoskins, C. H., Southern Portland Cement Ltd., Kembla Bldg., Margaret St., Sydney, N. S. W., Australia
Houk, Howard H., 1209 S. Court St., Montgomery Ala.
Houston, City of, City Hall, Houston, Tex. (H. L. Show, City Engr.)
Hovde, A. C. (See Capital Avenue Cement Works)
Howard, S. B., 26 Orchard St., Biddeford Maine
Howe, C. D., The Whelan Bldg., Port Arthur, Ont., Canada
Howe, Henry L. (See City of Rochester, N. Y. Director of Design and Construction)
Howe, H. N., 76 Porter Bldg., Memphis, Tenn.
Howell, C. H., c/o The J. G. White Engineering Corp., 2 A. San Juan de Letran 24, Mexico, D. F., Mexico
Howland, M. R., 2500 Peralta St., Oakland, Calif.
Hoyer-Ellefsen, A/S, P. O. Box 39, Oslo, Norway (August Gundersen, Chief Engr.)
Hoyt, C. R., St. George Hotel, Brooklyn, N. Y.
Hoyt, Glenn T., 80 Whitman Ave., Melrose, Mass.
Hubbard, Fred, 1200 City Park Bldg., Youngstown, Ohio
Hubbell-Hartgering & Roth, 2640 Buhl Bldg., Detroit, Mich. (Clarence W. Hubbell
Hubbell, Clarence W. (See Hubbell-Hartgering & Roth)
Huber, Lee, 1828 I St., Bedford, Ind.
Huber, Walter L., 1 Montgomery St., San Francisco, Calif.
Hud-Cin Building Products Inc., Van Keurer Ave., Jersey City, N. J. (W. H. Blackwood)
Hudson Block & Supply Co., Inc., 5274 Hudson Blvd., North Bergen, N. J. (W. J. Dicker, Gen Mgr.)
Hudson, W. G. (See Portland Cement Assn.)
Hughes, C. A., Room 203 Experimental Engineering Bldg., University of Minnesota, Minneapolis, Minn.
*Hughes, E. E. (See Franklin Steel Works)
Hughes, R. G., 152 Market St., Paterson, N. J.
Hull, Herbert F., Box 2037, Seattle, Wash.
*Hulsart, C. R. (See Universal Atlas Cement Co.)
Humberd, John L. (See Ready Mixed Concrete Co.)
Humboldt Mfg. Co., 2014 Nebraska Ave., Chicago, Ill (Louis H. Martens, Pres.)
Hume, Albert S., Cangallo 439, Buenos Aires, Argentina
Hume Pipe Co. (South Africa) Ltd., The, P. O. Box 204, Germiston, Transvaal, South Africa (Kenneth Ray)
Hume, Walter Reginald, Hume Steel Ltd., Kinnear House, King & Little Collins Sts., Melbourne, Australia
Humphrey, D. S., Euclid Beach Park, Cleveland, Ohio
Hunt & Co., Robert W., 53 Park Place, New York N. Y. (J. F. Davis)
Hunt & Co., Ltd., Robert W., 901 McGill Bldg., Montreal, Canada (F. O. Farey)
Hunt, Thomas D., 536 County City Bldg., Seattle, Wash.
Hunt, W., P. O. Box 340, Townsville, Queensland, Australia
Hunter, Harry B., Roof U. & P. Bldg., Memphis, Tenn.
Hunter, Russell H. (See Starrett Brothers & Eken, Inc.)
Huntington, W. C., 201 Engineering Hall, University of Illinois, Urbana, Ill.
Hurlburt, R. W., 52 York St., Toronto, Ont., Can.
Hurley, John J., 41 Bonair St., Somerville, Mass.
***Huron Portland Cement Co.,** Ford Building, Detroit, Mich. (J. W. Kennedy)
Huser, Dr. Ing. Alfred, Obercassel-Siegkreis, Germany
Hussey, Jack W., c/o Universal Atlas Cement Co., 1012 Baltimore Ave., Kansas City, Mo.
Hustad Company, The, 521 Sexton Bldg., Minneapolis, Minn. (A. P. Hustad, Pres.)
Hustad, A. P. (See The Hustad Company)
Hutchinson, G. W. (See Riverton Lime Co.)
Hutchinson, Jr., Hardye, 1450 Harrison St., Oakland, Calif.
Hutter, George F. (See Hutter Construction Co.)
Hutter Construction Co., 128 Western Ave., Fond du Lac, Wis. (George F. Hutter)
Hutton, S. E., 1542 17th Ave. No., Seattle, Wash.
Huxhold, P. F. (See Concrete Bldg. Units Co.)
Hyde, George A., c/o Chicago Stone Conduit Co., 3595 N. California Ave., Chicago, Ill.
Hydraulic Press Brick Co., South Park, Ohio
Hydro-Electric Power Comm., 190 University Ave., Toronto, Ont.
Hydropreat Products, Ltd., North Lincoln Rd., Scunthorpe, Lincs, England (A. Ogilvie)
Hynes, Ltd., W. J., 29 Birch Ave., Toronto, 5, Canada (W. S. P. Hannaford)
Idaho, Dept. of Public Works, Box 1467, Boise, Idaho (J. D. Wood)
Ideal Concrete Co., Inc., Joliet, Ill. (J. G. Sengenberger)
Ideal Concrete Co. Inc., 455 Rowell Ave., Joliet, Ill. (John G. Sengenberger)
Igoe Brothers, Ave. A & Pointer St., Newark, N. J. (Ralph F. Healy)

Illinois Division of Highways, Bureau of Materials, 100 E. Washington St., Springfield, Ill.
Illinois Steel Co., 208 S. LaSalle St., Chicago, Ill (E. B. Harkness)
Imlay, R. G., 704 East End Ave., Pittsburgh, Pa.
Immel Construction Co., 198 N. Main St., Fond du Lac, Wisc. (H. M. Mabie, Jr.)
Imprese Idrauliche Elettriche del Tirse, Sardegna, Cagliari, Italy
Independent Concrete Pipe Co., 201 N. West Street, Indianapolis, Ind. (R. D. Robertson)
Independent Concrete Pipe Co., Ltd., 198 Riddell St., Woodstock, Ont., Canada (James Carnwath)
Indian Hume Pipe Co. Ltd., The, Phoenix Building, Ballard Est., Bombay, India
***Indiana Portland Cement Co.,** Indianapolis Ind. (George E. Pierson, Mgr.)
Industrial Engineering Co., 30 Church St., New York City, N. Y. (D. Traver Miller)
Infante, Percival M., New York Central R. R. Lines, 466 Lexington Ave., New York, N. Y.
Ingberg, S. H., Bureau of Standards, Washington, D. C.
Ingemanson, Thure W., 5944 W. Erie St., Austin Sta., Chicago, Ill.
***Inland Steel Co.,** First Nat'l Bank Bldg., Chicago, Ill. (A. C. Roeth)
***Insley Mfg. Co.,** Indianapolis, Ind. (A. C. Rasmussen)
Integral Waterproofing Co., 300 Water St., New York, N. Y. (Frank J. Phelan)
International Cement Corp., 342 Madison Ave., New York, N. Y. (Howard Rhode)
***International Cement Corp.,** 342 Madison Ave., New York, N. Y.
***International Cement Corp.,** 342 Madison Ave., New York, N. Y.
Iowa Concrete Crib & Silo Co., 820 S. W. Ninth St., Des Moines, Iowa (H. E. Kilmer, Gen. Mgr.)
Iron City Sand & Gravel Co., Cumberland, Maryland
Irwin, Orlando W., 401 Alameda Ave., Youngstown, Ohio
Israil, Mohammad, c/o Maulana Maulavi Saiyed Mohd Abdul Hafeez Sahib, Galee Maulavi Abdul Hakin, Phatak Habash Khan, Delhi, India
"Italcementi", Fabriche Riunite Cemento, Bergamo, Italy (Carlo Vigliani)
Jack, Erick D., Waimea County Council, Nelson, New Zealand
Jack, Eugene C., P. O. Box 893, Bremerton, Wash.
Jack, W. A. (See Maine Concrete Co.)
Jacobson, C. W., 104 Greenhill Parkway, Worcester, Mass.
Jackson, F. H., U. S. Bureau of Public Roads, Washington, D. C.
Jackson-Lewis Co., The, 1114 Federal Bldg., Toronto, Ont., Canada (C. Blake Jackson, Pres.)
Jackson, C. Blake (See The Jackson-Lewis Co.)
Jackson & Moreland, 31 St. James Ave. Boston, Mass. (E. H. Cameron)
Jacoby, H. S., Hanna Bldg., Cleveland, O.
Jakhelln, Harald (See Christiania Portland Cementfabrik)
James, W. H., "Newlyn", 4th Ave., Joslin, Adelaide, South Australia
James, Proctor & Redfern, Ltd., 36 Toronto, St., Toronto, Ont. (W. D. Proctor)
James, William, 1609 Franklin Ave., St. Louis, Mo.
Jameson, R. O., 1005 Southwestern Life Bldg., Dallas, Texas
Jamestown Block & Tile Co., P. O. Box 712 Jamestown, N. Y., (D. A. McCune, Treas.)
Jeffers, Paul E., 816 West 5th St., Los Angeles, Calif.
Jeffrey, W. McKenzie, P. O. Box 1734, Auckland, N. Z.
Jellick, J. E., Calaveras Cement Company, 315 Montgomery St., San Francisco, Calif.
Jennings, Wm. A., Box 322, Osborn, Ohio
Jewett, John Y., Administration Bldg., Balboa Park, San Diego, Cal.
Jimenez L., Cesar, c/o Comision N. De Irrigacion, Estacion La Cruz, Chihuahua, Mexico
Joffe & Co., A. S., P. O. Box 4147, Johannesburg, S. Africa (A. S. Joffe))
Joffe, A. S. (See A. S. Joffe & Co.)
Joglekar, M. V., c/o Tata Constr. Co. Ltd., Phoenix Bldg., Ballard Estate, Fort, Bombay 10, India
Johns, H. S., Hillyard St., Hamilton, Ont., Canada
***Johns-Manville Corp.,** 292 Madison Ave., New York, N. Y. (Geo. A. Smith, Engr.)
Johnsen, E., c/o Francisco & Jacobus, 511 Fifth Avenue, New York, N. Y.
Johnson, A. (See Central Concrete Mixing Corp.)
Johnson, A. F., 1411 Foshay Tower, Minneapolis, Minn.
Johnson, Axel H., 1192 Gladys Ave., Cleveland, Ohio
Johnson, A. N. (See University of Maryland)
Johnson, A. W., 2037 Morse Ave., North Town Sta., Chicago, Ill.
Johnson C. H. (See Benson Concrete Co.)
Johnson Co., C. S., 1002 North Market St., Champaign, Ill (Chas. S. Johnson)
Johnson, Chas. S. (See C. S. Johnson Co.)
Johnson, H. E. (See Gulf Concrete Pipe Co.)
Johnston, Hugh H. (See South Dakota Concrete Products Co.)
Johnston, Harold S. (See The Nova Scotia Power Comm.)
*Johnston, J. W. (See Lone Star Cement Co.)
Johnson, Lewis J., Harvard University, Cambridge, Mass.
Johnson, L. E. (See The Finishing Lime Assn. of Ohio)
Johnson, Otis Floyd, 6016 Ellis Ave., Chicago, Ill.
Johnson, O. K., 1000 Franklin Ave., Waco, Texas
Johnson, Robert C., 19 W. Division St., Fond du Lac, Wisc.
Johnson, R. W. (See Concrete Reinforcing Steel Institute)
Johnston, Robert Smith, Bayside Blvd., Bayside, N. Y.
Johnson, T. H., 319 Iowa Bldg., Sioux City, Iowa
Johnson, Virgil L., 29 W. Upsal St., Germantown, Philadelphia, Pa.
Johnston, W. J., P. O. Box 1417, St. John, N. B., Canada
Johnson, W. P., c/o Meyers & Johnson, Commerce Bldg., Erie, Pa.
Johnson, Wm. R., Box 588, Cincinnati, Ohio
Jones, Bevan, 101 Park Ave., New York, N. Y.
Jones-Hettelsater Constr. Co., 707 Mutual Bldg., 13th & Oak St., Kansas City, Mo. (Edmund Wilkes)
Jones & Laughlin Steel Corp., South Side Works, Pittsburgh, Pa. (J. B. Carlock)
Jones, R. C., No. 233 Balboa Heights, Canal Zone
Jones, Walter E. (See Federal Concrete Co.)
Jones, William A., 148 Mahanoy Ave., Mahanoy City, Pa.
Jones, William M., 517 E. 28th St., Paterson, N. J.

Jorgensen, Lars, 1201 Hobart Bldg., San Francisco, Calif.
Jorss, Chris. A., P. O. Box 73, Maryborough, Queensland, Australia
Josephs, Arthur C., 300 E. Michigan St., Duluth, Minn.
Jourdan Concrete Pipe Co., Box 914, Fresno, Calif. (H. W. Chutter)
Kahler, G. A. (See Prairie Concrete Products Co.)
Kahn, Albert, Marquette Bldg., Detroit, Mich.
*Kahn, Julius (See Truscon Steel Co.)
Kaiser, B. J., 801 Keystone Bldg., Pittsburgh, Pa.
Kaiser Paving Co., 1522 Latham Sq. Bldg., Oakland, Calif. (T. M. Price)
Kalinka, J. E., c/o Roberts Schaefer Co., Wrigley Bldg., Chicago, Ill.
Kalman Floor Co., 410 N. Michigan Ave., Chicago, Ill. (C. E. Cooke)
***Kalman Steel Co.,** Wrigley Bldg., Chicago, Ill.
Kamat, V. A., Shahpoor House, 114 Cawasji Patel St., Fort, Bombay, India
***Kansas Portland Cement Co., The,** Federal Reserve Bank Bldg., Kansas City, Mo. (J. A. Lehaney, Vice-Pres.)
Kao, P. K., Chuny-Hwa Book Co., Mukden, China
Kaufman, David M., 80 Van Cortlandt Park South, New York, N. Y.
Kaye, Lister Lister, Southam Works, Rugby, England
Kealy, J. T. (See Binney & Smith Co.)
Kearney, James C., 1758 Penobscot Bldg., Detroit, Mich.
Kearney, Stephen (See Cinder Concrete Units Corp.)
Keatinge, Paul F., 208 S. LaSalle St., Chicago, Ill.
Keesee, Gerald B., P. O. Box 118, Brownwood, Texas
Keily, J. V. (See R. I. State Bd. of Public Roads)
Kelch, Norman (See Clay Products Institute of California)
Kellam, Fred, State Highway Commission, State House Annex, Indianapolis, Ind.
Kelly, E. W., 221 W. Victoria St., Duluth, Minn
Kelley, Frederick W., 40 Howard St., Albany N. Y.
Kelley, J. W., 5328—2nd Ave. So., Minneapolis, Minn.
Kemmer, A. E., Lafayette, Indiana
*Kennedy, J. W. (See Huron Portland Cement Co.)
Kennedy, W. A. (See Reichard-Coulston, Inc.)
Kennoy, John S., 220 Golden Gate Ave., San Francisco, Calif.
Kentucky State Highway Dept., Frankfort, Ky. (J. S. Watkins)
Kerr, Frank O. (See College of Engineering, University of Porto Rico)
Kerr, G. M. (See Core Joint Concrete Pipe Co., Inc.)
Kerr, George W., State Highway Dept., 307 Trust Bldg., Newark, Ohio
Kerr, Linton, 49 Federal St., Boston, Mass.
Kerwin, P. A. (See Dept. of Street Railways, Detroit, Mich.)
Ketchum, M. S., Dean of College of Engineering, University of Illinois, Urbana, Ill.
*Kichline, H. F. (See North American Cement Corp.)
Kienstra Bros. Fuel & Supply Co., Wood River, Ill. (Frank T. Kienstra)
Kienstra, Frank T. (See Kienstra Bros. Fuel & Supply Co.)
Kikkeri, S. A., B. E., c/o Treasury Officer, T. Narsipur, Mysore, S. India
Killian, M. B., c/o R. W. Briggs & Co. Victoria, Texas
Kilmer, H. E. (See Iowa Concrete Crib & Silo Co.)
Kimpton, A. C., Casebourne & Co., Ltd., "Pioneer" Cement Works, Haverton Hill, nr. Middbr., England
Kindle, W. H., 798 Broadway, Newark, N. J.
King, A. W. (See Consolidated Cement Corp.)
King, Thomas H., 716 Electric Bldg., San Diego, Calif.
King, W. E., Builders Exchange Bldg., St. Paul, Minn.
Kinneman, W. P., 140 Cedar St., New York, N. Y.
Kinney, Wm. M., 33 W. Grand Ave., Chicago, Ill.
Kirchhof Constr. Co., F. J., 700 Lawrence St., Denver, Colo. (F. J. Kirchhof)
Kirchhof, F. J. (See F. J. Kirchhof Constr. Co.)
Kirk, Joe Neil, 115 Drexel Ave., Lansdowne, Pa.
Kirwan, Kenneth K., 923 Munsey Bldg., Baltimore, Md.
Kitson, C. O. (See Blue Ridge Talc. Co., Inc.)
Kivett, Edward H., Louisiana Highway Commission, Baton Rouge, La.
Klank, Willy, c/o Struck. Galvanistr. 6, Berlin-Charlottenburg, Germany
Klassy, K. H., Stockton, Ill.
Klein, W. H., Pennsylvania-Dixie Cement Co., 1010 James Bldg., Chattanooga, Tenn.
Kleinlogel, Prof. Adolf, Roquetteweg 33, Darmstadt, Germany (Hessen)
Kleinsteuber, M. E. (See Cut Art Stone Co.)
Kling, E. E. (See Youngstown Burial Vault Co.)
Klingensmith, F. (See American Hume Concrete Pipe Co.)
Klinger, W. A., Warnock Bldg., Sioux City, Iowa
• **Klock, Morgan B.,** 25 E. Jefferson Road, Pittsford, N. Y.
Klotz, Paul R. (See Hollywood Building Block Co.)
Kneeland, H. D. (See Calif. Stucco Products Co.)
Kneeshaw, F. P., Gen. Mgr., G. P. O. Box 2613 EE, 66 Pitt St., Sydney, N. S. W., Australia
Kneisel, Dr. Rudolf (See Verein Deutscher Portland)
Knight, W. J., Pres., W. J. Knight & Co., 903 Warnerright Bldg., St. Louis, Mo.
Knopel, Herbert J., Warner Company, 1518 Walnut St., Philadelphia, Pa.
Knox, Jean H., 1142 N. Edgefield Blvd., Dallas, Texas
***Koehring Company,** 31st & Concordia Ave., Milwaukee, Wis. (Philip Koehring)
***Koehring Company,** 31st & Concordia Ave., Milwaukee, Wis. (E. H. Lichtenberg)
Koehring, Philip (See Koehring Company)
Koenig Coal & Supply Co., 1480 Gratiot Ave., Detroit, Mich. (A. J. O'Connor)
Koepke Bros. Const. Co., 201 E. College Ave., Appleton, Wisc. (G. A. Koepke)
Koepke, G. A. (See Koepke Bros Const. Co.)
Koerner, Carl A., 1601 Syndicate Trust Bldg., St. Louis, Mo.
Koenitzer, L. H., Kansas State College, Box 217, Manhattan, Kans.
Kohli, T. N., Dhakpuri, Alwar City (Rajputana) India
Kolinski, M. C., Pres., Kolinski Ready Mixed Concrete Co., 127 S. 11th St., Milwaukee, Wisc.
Komuro, Mangoro, Iwaki Cement Co. Ltd., Yotsukuracho, Fukushimaken, Japan
Kondow, Yasuo, Kyoto Imperial University, Kyoto, Japan
***Kosmos Portland Cement Co.,** 1430 Starks Bldg., Louisville, Ky. (A. W. Horner)

Krabbe, A. F. (See The Olympic Portland Cement Co. Ltd.)
Kraus Process Inc., 110 W. 40th St., New York, N. Y. (J. Tyrell Cheney, Pres.)
Krauss, John S. (See Winslow Construction Co.)
Krause, G. E., Juneau, Alaska
Krause, L. B., 239 S. La Salle St., Chicago, Ill.
Krehbiel, B. F. (See Cement Stone & Supply Co.)
Kreidler, Carl L., Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pa.
Kremers, Ernest (See Wright & Kremers, Inc.)
Kressly, Paul E., 1780 Ramiro Road, San Marino, Calif.
Krewatch, Wm., 13 S. Ann St., Lancaster, Pa.
Kriege, Herbert F., 1219 W. Bancroft St., Toledo, Ohio
Krier, George H., 814 E. 94th St., Brooklyn, N. Y.
Kronkvist, Hans, Aktiebolaget Skanska Cementgjuteriet, Malmo, Sweden
Kuan, F. C., 118 Cook St. Ithaca, N. Y.
Kubitz, Fred, 427 Oliver Bldg., Pittsburgh, Pa.
Kuemmerle, Clarence E. (See Artcrete Products Co.)
Kuhlman Bldrs. Supply & Brick Co., The, 1428 Nicholas Bldg., Toledo, Ohio (C. E. Kuhlman)
Kuhlman, C. E. (See The Kuhlman Bldrs. Supply & Brick Co.)
Kynnersley, T. R. S., c/o Concrete Association of India, E-2 Clive St., Calcutta, India
Labastille, William M., P. O. Box 586, Downers Grove, Ill.
Laboratorio Prove Materiali, Della R. Scuola di Ingegneria, Piazza Cavour 4, Milano 113, Italy (Giulio Revere)
La Camera, Peter, 48 Chandler Ave., Detroit, Mich.
***Laclede Steel Co.**, 1317 Arcade Bldg., St. Louis, Mo. (W. W. Scott)
LaDue, R. M. (See McCracken Machinery Co.)
Lagaard, M. B., c/o Minneapolis Bridge Co., 701 Metropolitan Life Bldg., Minneapolis, Minn.
Lago Petroleum Corp., Apartado 172, Maracaibo, Venezuela (R. L. Mitchell, Ch. Engr.)
Lain, John Sayers-, 133 15th Ave., E., Calgary, Alta., Canada
Lake Ports Supply Co., The, 1917 Penobscot Bldg., Detroit, Mich.
Lake, Simon, East Main St., Stratford, Conn.
Laker Concrete Works, Dalton, Mo. (H. J. Laker)
Laker, H. J. (See Laker Concrete Works)
Lakewood Engineering Co., 520 Dublin Ave., Columbus, Ohio (Lion Gardiner, Vice-Pres.)
LaLonde, Jean Paul, 2042 Marlowe, Ave. Montreal, Canada
Lamar Pipe & Tile Co., 431 Michigan Trust Bldg., Grand Rapids, Mich. (C. E. Edwards, Gen. Mgr.)
Lamb Co., Robert E., 843 North 19th St., Philadelphia, Pa. (Robert E. Lamb)
Lamb, Robert E. (See Robert E. Lamb Co.)
Lambert, Edward A. (See Fletcher, Thompson, Inc.
Lambie, J. Edward, 160 East 156th St. & Lake Shore Dr., Cleveland, Ohio
Lambie, Joseph S., 703 Diamond Bank Bldg., Pittsburgh, Pa.
Lancaster Concrete Tile Co., Lancaster Pa. (Henry Boettcher, Pres.)
Landa, German, Ave. P. Carranza No. 56, Coyoacan, D. F., Mexico
Lander, R. S., Box 196, Little Rock, Ark.
Landor, Edward J., 634 Renekert Bldg., Canton, Ohio
Lane, H. A., Baltimore & Ohio Central Bldg., Baltimore, Md.
Lang, F. C. (See Minn. Highway Dept.)
Lang, Jr., Philip George, 1300 Baltimore & Ohio Bldg., Baltimore, Md.
Langdon, E. W., c/o Joseph T. Ryerson & Son Inc., 2558 West 16th St., Chicago, Ill.
Langeler, M. Bert, 3041 E. 79th Place, Chicago, Ill.
Langlais, Zachee, 126 Rue St. Pierre, Quebec, Canada
Lansford, Wallace M., 314 Materials Testing Laboratory, University of Illinois, Urbana, Ill.
Lapham, John A., 4800 Arkansas Ave., N. W., Washington, D. C.
Large, G. E., 776 S. Remington Road, Columbus, Ohio
Larkin, Chas. W., Carnegie Institute of Technology, Pittsburgh, Pa.
Larsen-Morgan Co., 6th St. at Iowa, Oshkosh, Wis. (R. W. Morgan)
Larson, D. E., 10208 S. Wood St., Chicago, Ill.
Larson, Guy H., Materials Department, Wisconsin Highway Comm., Madison, Wisc.
Larson, Louis J., 3306 N. Shepard Ave., Milwaukee, Wisc.
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Laubscher, R. E. (See The Sam W. Wmerson Co.)
Lavelle, J., General Assurance Bldg., Toronto, Ont., Canada
Lavoie & Delisle, Chicoutimi, Que., Canada
***Lawrence Portland Cement Co.**, 270 Broadway Ave., New York, N. Y. (E. P. Haubert)
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Le Soliditit Francais, 55 Rue de Lyon, Paris, France
Lee, Kung, c/o Building Sect., Anderson, Meyer & Co., Ltd., Yuen Ming, Yuen Road, Shanghai, China
Lee, Smith & VanDervoort, 15 N. 11th St., Richmond, Va. (Jameson VanDervoort)
Lee, W. S., Power Bldg., Charlotte, N. C.
Leffler, Ralph R., 7021 Oriole Ave., Chicago, Ill.
*Lehaney, J. A. (See The Kansas Portland Cement Co.)
Lehigh Portland Cement Co., Young Bldg., Allentown, Pa.
***Lehigh Portland Cement Co.**, Allentown, Pa. (E. M. Young, Pres.)
***Lehigh Portland Cement Co.**, Allentown, Pa. (E. M. Young, Pres.)
***Lehigh Portland Cement Co.**, Young Bldg., Allentown, Pa.
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Leslie, J. R. (See Leslie Engineering Co.)
Levison, Arthur A., c/o Blaw-Knox Co., P. O. Box 915, Pittsburgh, Pa.
Lewis Asphalt Engineering Corp., 30 Church St., New York, N. Y. (R. W. Lewis)
Lewis, H. J., City Hall, Muskegon, Mich.
Lewis, R. W. (See Lewis Asphalt Engineering Corp.)
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Liebeskind, Morris Moe, 1931 Walton Ave., Bronx, New York City
Liggett, J. J. (See Van Camp Stone Co.)
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Lindsay & Co., Inc., W. W., 902 Harrison Bldg., Philadelphia, Pa. (James C. Newlin)
Lindsley Co., C. E., 888 Clinton Ave., Irvington, N. J. (C. E. Lindsley, Treas & Mgr.)
Lindsley, C. E. (See C. E. Lindsley Co.)
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Little, C. E. (See Super Concrete Emulsions, Ltd.)
Livermore, A. C., Wilmerding, Pa.
Lock Joint Pipe Co., Ampere, N. J. (A. M. Hirsch, Pres.)
Lock Joint Pipe Co., Ampere, N. J. (J. E. Longley)
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Loeb, II, Henry, Loeb Stone Co., Memphis, Tenn.
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Lomer, G. E. (See McGill University Library)
***Lone Star Cement Co.,** 225 South 15th St., (H. E. Hilts)
***Lone Star Cement Co.,** Sante Fe Bldg., Dallas, Texas (L. R. Ferguson)
***Lone Star Cement Co.,** Birmingham, Ala. (J. W. Johnston)
***Lone Star Cement Co., Virginia, Inc.,** Norfolk, Va. (Dwight Morgan)
***Lone Star Cement Co.,** 1120 Hibernia Bank Bldg., New Orleans, La. (Scott Thompson)
***Lone Star Cement Co., New York, Inc.,** 100 State St., Albany, New York (D. P. Cooper)
Longfellow, D. W. (See Elk River Concrete Products Co.)
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Los Angeles Public Library, 530 So. Hope St., Continuations Division, Los Angeles, Calif. (Albert C. Read)
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Loughlin, L. J. (See Toledo Concrete Pipe Co.)
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Love, Harry J., 937 Leader Bldg., Cleveland, Ohio
Lovejoy, C. H. (See The Forest City Testing Laboratory)
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Lundoff-Bicknell Co., The, 2024 B. F. Keith Bldg., Cleveland, Ohio (C. W. Lundoff)
Lundoff, C. W. (See Lundoff-Bicknell Co.)
Lundteigen, A., V. P., Ash Grove Lime & Portland Cement Co., Kansas City, Mo.
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Lynam, C. G., Turkish Petroleum Co. Ltd., Fields Headquarters, Tuz-Khurmatli, Mesopotamia
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Lynch Co., W. J., 844 Rush St., Chicago, Ill

Lynds, C. D. (See The Sandstone Quarries Co.)
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McCall, H. H. (See Los Angeles Testing Laboratory)
McCanless, W. F. (See Ornamental Stone Co.)
McCann, Wm. B. (See Australian Cement Ltd.)
McCarty, M. I. (See Electric Tamper & Equipment Co.)
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McCracken, Jas. F. (See American Builders Supply Co.)
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McKenzie, C. L. (See Duquesne Slag Products Co.)
McKenzie, B. Stuart (See Canadian Engineering Standards Assn.)
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McKenzie, N. H. (See Bedford Construction Co.)
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McMillan, Franklin R., 33 W. Grand Ave., Chicago, Ill..
McMorrow, John T. (See Boston Transit Mixers, Inc.)
McNiven, J. A., 2 Canal St., New Orleans, La.
McNulty, Joseph A., 114 Liberty St., New York, N. Y.
McQuestion, Hubert (See N. Shore Cement Burial Vault Co.)
McRae Steel Co., 509 Free Press Bldg., Detroit, Mich. (K. C. McRae)
McRae, K. C. (See McRae Steel Co.)
McThenia, A. W., Acme Limestone Co., Alderson, W. Va.
McWilliam, R. J., Exton House, Queen St., Brisbane, Australia
McWilliams, R. (See Republic Fireproofing Co., Inc.)
Mabie, H. W., Jr., (See Immel Construction Co.)
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Mack, Thomas, 6610 S. Menard Ave., Chicago, Ill.
Mack, W. W. (See Delaware State Highway Dept.)
Mackie, Jas. A., J. & W. Henderson Ltd., 82 Market St., Aberdeen, Scotland
Mackie, Thos. W., c/o Morrow & Beatty Ltd., Fitzroy Harbor, Ont., Canada
Mackenzie, W. F. (See Pretoria Portland Cement Co., Ltd.)
MacKenzie, W. S., Smith, Hinchman & Grylls, Marquette Bldg., Detroit, Mich.
Mackney, A. E., Mgr., Macdonald & Macdonald, 923 Birks Bldg., Vancouver, B. C., Canada
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MacNaughton Co., Inc., P. J., 755 Boylston St., Boston, Mass. (P. J. MacNaughton)
MacNaughton, P. J. (See P. J. MacNaughton Co. Inc.)

Macneal, LeRoy C., 284 S. Columbus Ave., Mt. Vernon, N. Y.
Macomber, C. Clark, 38 Chauncy St., Boston, Mass.
Made-Rite Products Co., 5223 McKissock Ave., St. Louis, Mo. (Robert Fullerton, V. P.)
Madison Silo Co., 719 Beaver Bldg., Madison, Wis. (C. C. Woody)
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Magny, A. V., Plateau St. Hillaire, Grasse A. M., France
Maguire Co., Chas. B., 507 Grosvenor Bldg., Providence, R. I. (Chas. A. Maguire)
Maguire, Chas. A. (See Chas. B. Maguire Co.)
*Maguire, E. J. (See Manitowoc Portland Cement Co.)
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Maine Concrete Co., Main St., Brunswick, Me. (W. A. Jack)
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Manitoba Library, University of, Kennedy St., Winnipeg, Manitoba (J. N. Finlayson)
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Mantelli. I. (See Ing. Mantelli, Reg. Corbella & Co.)
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Marquette Cement Mfg. Co., LaSalle, Ill. (C. M. Butler, Chief Chemist)
***Marquette Cement Mfg. Co.,** Marquette Bldg., Chicago, Ill. (R. R. Coghlan, Chemical Engr.)
Marsden, R. W., 16 Norwood Rd., Headingley, Leeds, York, England
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Marsh, V. L. (See Wurster Construction Co.)
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Martens, Louis H. (See Humboldt Mfg. Co.)
Martel, R. R. (See Calif. Inst. of Technology)
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Martinez, Jose Ricardo, Prado 111, Havana, Cuba
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Mason, Philip A. (See City of Hartford)
Mason, Roscoe J., 3221 Lenox Ave., Detroit, Mich.
Masonite Corp., 111 W. Washington St., Chicago, Ill. (E. B. Bushnell)
***Massey Concrete Products Co.,** 968 Peoples Gas Bldg., Chicago, Ill. (E. C. Alexander)
Master Builders Co., The, 7016 Euclid Ave., Cleveland, Ohio (S. W. Flesheim)
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Matthews, L. H., Stone & Webster Eng. Corp., 49 Federal St., Boston, Mass.
Mattison, Jr., Geo. A. (See Woodstock Slag Corp.)
Mattison, Richard V. (See Asbestos Shingle Slate & Sheathing Co.)
Mauro, Francesco, 4437 Chestnut St., Philadelphia, Pa.
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Mead-Suydam Co., 400 Sheridan St., Orange N. J. (F. J. Mead, Pres.)
Mead, F. J. (See Mead-Suydam Co.)
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Meldrum, T. J. (See American Memorial Co.)
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Mercer, L. Boyd, c/o Henry Simon Ltd., Cheadle Heath, Stockport, Cheshire, England
Merchant, Archie W., 728 Hospital Trust Bldg., Providence, R. I.
Merlo, Louis Alvin (See Merlo, Merlo & Ray Ltd.)

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Metropolitan Concrete Co., Western Reserve Bldg., Superior & W. 9th St., Cleveland, Ohio (W. H. Crangle)
Metzger-Richardson Co., Century Bldg., Pittsburgh, Pa. (F. L. Metzger)
Metzger, F. L. (See Metzger-Richardson Co.)
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Meyer, B. A. (See Meyer, Morrison & Co.),
Meyer, C. Louis, 1141 No. 11th St., Omaha, Nebr.
Meyer, Geo. W. (See The Ross-Meyer-Hecht Co.)
Meyer & Holler Inc., 315 Wright & Callender Bldg., Los Angeles, Calif. (R. Howard Armin)
Meyer, Morrison & Co., 39 Cortlandt St., New York, N. Y. (B. A. Meyer, Pres.)
Meyer, M. W. (See Anti-Hydro Waterproofing Co.)
Michigan Concrete Co., 14445 Hamilton Ave., Detroit, Mich. (E. H. Bingham)
Michigan State College, Civil Engineering Dept., East Lansing, Mich. (C. L. Allen)
Michigan, University of, Transportation Library, East Engineering Bldg., Ann Arbor, Mich. (R. L. Morrison)
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Milgram, Joseph, (See Nelson Pedley Construction Co.)
Millen, Vincent, c/o Chirigui Land Co., Puerto Armuelles, Rep. of Panama, C. A.
Miller, D. Traver, (See Industrial Engineering Co.,)
Miller, F. E. (See Standard Slag Co.)
Miller, G. R., S. M. Damon Bldg., Honolulu, Hawaii
Miller, J. G. (See Great Lakes Concrete Pipe Co., Inc.)
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Miller, N., c/o Beauharnois Construction Co., Box 50, Beauharnois, Que., Canada
Miller, O. H. (See Hollywood Concrete Pipe Co.)
Millhouse, C. C. (See The Automatic Sealing Vault Co.)
Milligan, Mr. (See John V. Gray Construction Co.)
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Minnesota Highway Dept., 1246 University Ave., St. Paul, Minn. (F. C. Lang, Engr. of Tests and Inspection)
Minnesota Mining & Mfg. Co., Forest & Fauquier Sts., St. Paul, Minn. (L. A. Hatch)
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Minwax Company, Inc., 11 West 42nd St., Allrich S. Harrison, Vice-Pres.)
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Mitchell, Thos. H., c/o The H. K. Ferguson Co., Marunouchi Bldg., Tokyo, Japan
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Mock, Dr. Wm. (See Messinger Supply Co.)
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Morgan, R. W. (See Larsen-Morgan Co.)
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Morrill, George P., Westbrook, Conn.

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Morris, Mark, c/o Iowa State Highway Commission, Ames, Iowa
Morris, S. B. (See Pasadena Water Dept.)
Morrison, Phillip (See Pioneer Sand & Gravel Co.)
Morrison, R. L. (See Univ. of Michigan)
Morrow & Beatty Ltd., Fitzroy Harbour, Ont., Canada (J. A. Beatty, V. P.)
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Mott, John (See Clinton Metallic Paint Co.)
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Mueller, J. W., Palladium Bldg., Richmond, Ind.
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Muirhead Construction Co., Wm., Durham, N. Car. (Wm. Muirhead)
Muirhead, Wm. (See Wm. Muirhead Construction Co.)
Mulroy-Cooke Co., Inc., 636 Ogden St., Newark, N. J. (E. J. Mulroy, Pres.)
Mulroy, E. J. (See Mulroy-Cooke Co., Inc.)
Mumm, Jr., Hans (See Everett Concrete Products Co.)
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Murphy, F. E. (See Stevens & Wood, Inc.)
Murphy, Frank J. (See Valentine Lumber & Supply Co.)
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Murray, Inc. Thomas E., 88 Lexington Ave., New York, N. Y. (J. R. McColl)
Muth, G. M. (See Berks Building Block Co.)
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Myren, B. J. (See N. P. Severin Co.)
Myron, J. A., c/o Cincinnati Union Terminal Co., 1020 Temple Bar Bldg., Cincinnati, Ohio
National Fireproofing Co., 122 E. 42nd St., New York, N. Y. (Philip Bevier)
National Lime Association, 927 Fifteenth St. N. W., Washington, D. C. (W. V. Brumbaugh)
National Paving Brick Mfgrs. Assn., National Press Bldg., Washington, D. C. (G. F. Schlesinger)
Nag, N. K., Cooch Behar, Bengal, India
Nailcrete Corp., The, 105 W. 40th St., New York, N. Y. (F. B. DeGross)
Naito, Tachu, Univ. of Waseda, Tokyo, Japan.
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Nashville Breeko Block & Tile Co., 306 Cowan St., Nashville, Tenn. (Chas. Wm. Akers, Mgr.)
***Nassau Sand & Gravel Co.,** 17 Battery Place, New York, N. Y. (W. J. Timberman)
Nasu, Akiya, Mgr., Nakashibuya No. 715, Tokyo, Japan
***National Building Units Corp.,** 1600 Arch Street, Philadelphia, Pa.
National Cement & Block Supply Co., The, Wayne St. at Terminal R. R., Toledo, Ohio (C. B. Fellabaum)
National Crushed Stone Assn., 14th & S Sts. N. W., Washington, D. C. (A. T. Goldbeck)
***National Equipment Corp., The,** 31st & Concordia Aves., Milwaukee, Wis.
National Steel Fabric Co., Union Trust Bldg., Pittsburgh, Pa. (W. H. Shaffer, Jr.)
National Testing Laboratories Ltd., The, 223 James St., Winnipeg, Man., Canada (L. J. Street)
***Nazareth Portland Cement Co.,** Nazareth, Pa.
Neff, F. H. (See Case School of Applied Science)
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Neill, W. A. (See The Dorr Co., Inc.)
Nelson, Ned H. (See Pacific Coast Cement Co.)
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Nelson, Dewey, Knollwood Road, Reading, Mass.
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Nelson, Norman, Cincinnati, Ohio.
Nelson Pedley Construction Co., 1510 Chestnut St,, Philadelphia, Pa. (Joseph Milgram)
Nepenna Building Materials Co., P. O. Box 427, Kingston, Pa. (F. L. Schott)
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***Newaygo Portland Cement Co.,** Newaygo, Mich.
Newcomb, Rexford, University of Illinois, 118 Architecture Bldg., Urbana, Ill.
Newhard, E. P. (See Pennsylvania Dixie Cement Corp.)
New Jersey Zinc Co., Palmerton, Pa.
Newlin, James C. (See W. W. Lindsay & Co., Inc.)
Newton, A. I. (See Berkshire Gravel Co.)
Nicholson, Geo. E., Pres., National Cement Co., 819 Commerce Bldg., Kansas City, Mo.

Nickel Plate Sand & Gravel Co., 610 Commerce Bldg., Erie, Pa. (H. F. Rath, Sec.)
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*Nichols, C. E. (See Stone & Webster)
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Nichols, John R., 45 Newbury St., Boston, Mass.
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Nielsen, S. W., Fountain City, Tenn.
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Nonporite Pty. Ltd., 296 Burwood Rd., Hawthorne, Vict., Australia (Norman Griffith)
Noonan, W. H., 334 Roy Bldg., Halifax, Nova Scotia, Canada
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Noren, Bertil, OR. Dalsland, Sweden
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Norris, J. F., 107 Norris St., Rochester, N. Y.
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***North American Cement Corp.**, 285 Madison Ave., New York, N. Y. (Thomas G. Mooney)
North American Cement Corp., Catskill, N. Y. (G. A. Witte)
***North American Cement Corp.**, Catskill, N. Y. (H. F. Kichline, Chief Chemist)
Northern Construction Co., Ltd., Vancouver Block, Vancouver, B. C., Canada (Wm. Smaill)
Northern States Power Co., 15 South Fifth St., Minneapolis, Minn. (G. E. Loughland)
Northeastern University, 316 Huntington Ave., Boston, Mass. (Henry B. Alvord)
North Jersey Dist. Water Supply Comm., 24 Commerce St., Newark, N. J. (Arthur H. Pratt)
Northwest Concrete Products Assn., 518 Exchange Bldg., Seattle, Wash. (F. R. Zaugg)
North Shore Cement Burial Vault Co., 2503 Buchanan Rd., Kenosha, Wis. (Hubert McQuestion)
Northwest Steel Rolling Mills, Inc., 4315 9th Ave., N. W., Seattle, Wash. (Paul H. Steuding, Sales Mgr.)
Northwestern States Portland Cement Co., Mason City, Iowa (G. C. Blackmore)
Northwestern Terra Cotta Co., The, W. 1st Ave. & Umatilla St., Denver, Colo. (Geo. W. Mueller)
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Nova Scotia Power Comm., The, Halifax, Nova Scotia (Harold S. Johnston)
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Nutting Co., H. C., 71st St. P. O. Box 1805, Cincinnati, Ohio (C. O. Christy)
Ober, R. H., Thompson Bldg., Seattle, Wash.
Ochs, Erie J. (See Standard Portland Cement Co.)
O'Connor, A. J. (See Koenig Coal & Supply Co.)
Oehmann, John W., 110 District Bldg., Washington, D. C.
Oesterblom, I., 1517 So. Michigan Ave., Chicago, Ill.
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Ogilvie, A. (See Hydroprest Products Ltd.)
Ohtomo, Kosuke, c/o Chichibu Cement Co., Chichibu, Saitama-Ken, Japan
Oklahoma A. & M. College, Library, Stillwater, Okla. (Mrs. Elsie D. Hand, Libr.)
Oklahoma Glazed Cement Pipe Co., Tulsa, Okla. (J. M. Chandler, Pres.)
Oklahoma Testing Laboratories, 519½ West Main St., Oklahoma City, Okla. (Wm. Furber Smith)
Okubo, Toshiyuki, 12 Furuichi Machi, Seoul, Korea, Japan
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Oliver, William A., 602 W. Church St., Champaign, Ill.
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Olsen, Eugene F. (See Consolidated Concrete Machinery Co.)
Olsen, Ole K., 822 Perdido St., New Orleans, La.
Olympic Portland Cement Co., Ltd., The, P. O. Box 17, Bellingham, Wash. (A. F. Krabbe, Gen. Supt.)
***Olympic Portland Cement Co.**, 4125 Dexter Horton Bldg., Seattle, Wash. (W. P. Cameron)
Olympian Stone Company, 6401 Seaview Ave., Seattle, Wash. (Leo Swartz)
Onoda Cement Co., Ltd., Dairen Branch Works, Dairen, South-Manchuria, China (K. Mizoguchi)
Onoda Cement Co., Yamaguchi-Ken, Japan
Orbeck, Martin J., c/o Holland, Ackerman & Holland, 106 E. Liberty St., Ann Arbor, Mich.
Ornamental Stone Co., Charlotte, N. C. (W. F. McCanless, Pres.)
Ornelas, Samuel, Comision Nacional de Irrigacion, Est La Cruz, Chih., Mexico.
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Osborn Co., C. J., 132 Nassau St., New York, N. Y. (W. F. Purdy)
Osborn, K. H. (See The Osborn Engineering Co.)
Osborne, Raymond G., Basement, Marsh-Strong Bldg., 9th & Main St., Los Angeles, Calif.
Oscar, L. C., Lehigh Portland Cement Co., Young Bldg., Allentown, Pa.

Osler, Richard B., The Cement Marketing Co., Portland House, Tothill St., Westminster, London, Eng.
***Ottawa Silica Co.,** Ottawa, Ill. (P. S. McDougall, Gen. Mgr.)
Ottawa Suburban Roads Commission, 279 Carling Ave., Ottawa, Canada (Alan K. Hay)
Outzen, Andrew N., Supt., River Rouge Co., 415 Clifford, Detroit, Mich.
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Oxley, J. Morrow (See Chapman & Oxley)
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Pacific Coast Steel Corp., Terminal Box 3147, Seattle, Wash. (W. A. Roth)
Pacific Coast Talc Co., 2149 Bay St., Los Angeles, Calif. (Geo. Ames, Mgr.)
Pacific Stone Co., The, 4257 Eighth Ave., N. W., Seattle, Wash. (Gilbert E. Tucker)
Painter, Geo. M., Belmont Cement Burial Case Co., West Manayunk, Pa.
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Palmer, E. W. (See Riley, Harbord & Law)
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Pargas Kalkbergs Aktiebolag, Pargas, Finland
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Penker Construction Co., The, 1030 Summer St., Cincinnati, Ohio (Irwin A. Penker, Pres.)
Penker, Irwin A. (See The Penker Contr. Co.)
Penniman Concrete & Material Co., 3000 Junius St., Dallas, Texas (Nolan Browne, V. P.)
Pennsylvania-Dixie Cement Corp., 521 Fifth Ave., New York, N. Y. (Blaine S. Smith, Pres.)
Pennsylvania-Dixie Cement Corp., 1010 James Bldg., Chattanooga, Tenn. (E. P. Newhard)
Pennsylvania State Highway Dept., Harrisburg, Pa. (W. H. Connell, Asst. State Highway Comm.)
Pennsylvania Water & Power Co., 1611 Lexington Bldg., Baltimore, Maryland (N. B. Higgins, Asst. Ch. Engr.)
Perfected Burial Vault & Cement Products Co., 2506-10 Irving Pk. Blvd., Chicago, Ill. (H. A. Dahlquist, V. P.)
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Peters, Strange & Bradshaw, 617 Myrick Bldg., Lubbock, Texas (N. L. Peters)
Peterson, Ivan C. (See Suhr, Berryman, Peterson & Suhr)
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Phelan, Frank J. (See Integral Waterproofing Co.)
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Pierce, George (See Pierce Testing Laboratories)
Pierson, James T. (See J. W. Pierson Co.)
Pierson, George E. (See Indiana Portland Cement Co.)
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Pioneer Sand & Gravel Co., 901 Harrison St., Seattle, Wash. (Phillip Morrison)

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Pitner, L. E. (See Cincrete Products Corp.)
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Pohlman, E. C. (See Materials, Inc.)
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Pollak, Julian A. (See The Pollak Steel Co.)
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P'Pool, A. O. (See A. P'Pool & Son)
Porcheddu, G. A. (See Soc. Porcheddu Ing., G. A.)
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Poriss Co., The S. C., 198 N. Quaker Lane, West Hartford, Conn. (S. C. Poriss)
Poriss, S. C. (See S. C. Poriss Co.)
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Powers, J. W. (See Arizona Highway Dept.)
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Powers, Treval C., Portland Cement Assoc., 33 West Grand Ave., Chicago, Ill.
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Praeger, Emil, 152 Stratford Rd., Brooklyn, N. Y.
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Pratt, Arthur H. (See North Jersey District Water Supply Commission)
Pratt, K. H. (See The Bolton Pratt Construction Co.)
Preis, C. G. (See American Can Co.)
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Price, T. M. (See Kaiser Paving Co.)
Priest, George E. (See Rib-Stone Concrete Corp.)
Priester Construction Co., 1121 American Bank Bldg., Davenport, Iowa (O. F. Priester)
Priester, O. F. (See Priester Construction Co.)
Prince, John, 1805 Grand Ave., Kansas City, Mo.
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Proctor, W. D. (See James, Proctor & Redfern, Ltd.)
Props of Hay's Wharf Ltd., Tooley St., London, S. E. I. England (H. J. M. Skidmore)
Proudley, C. E., Munsey Bldg., Washington, D. C.
Providence Transit Concrete Corp., 40 Allens Ave., Providence, R. I.
Punjab Portland Cement, Ltd., Wah, N. W. Railway, Attock District, Punjab, India
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Quaglia, Prof. Giovanni (See Regia Scula D' Ingegneria di Pisa)
Quebec, City of, City Hall, Quebec, Que., Canada (Edouard Hamel, C. E.)
Quebec Dept. of Public Works, Government Buildings, Quebec, Canada (Ivan E. Vallee)
Quebec, Department of Roads, Parliament Buildings, Quebec, Canada (J. L. Boulanger)
Queensland Main Roads Commission, Brisbane, Australia (J. E. England)
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Rackle & Sons Co., The Geo., Station D, Cleveland, Ohio (Geo. L. Rackle, V. P.)
Rackle & Sons Co., The George, Box 1778, Station D, Cleveland, Ohio (E. E. Rackle, Pres.)
Rackle, Geo. L. (See The George Rackle & Sons Co.)
Radbill, Ray, Moylan, Pa.
Rader, B. H., Conway Bldg., Chicago, Ill.
Radigan Frank J., Court House, Jersey City, N. J.
Raeder, Warren, University of Colorado, Boulder, Colo.
Rail Steel Bar Association, Builders Bldg., 228 N. LaSalle, Chicago, Ill. (H. P. Bigler)
Ramm Co., E. L., Tilden Ave., LaGrange, Ill. (E. L. Ramm)
Ramm, E. L. (See E. L. Ramm Co.)
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Randolph, Edward Sydney, Designing Engineer, Madden Dam, The Panama Canal, Box 72, Balboa Heights, C. Z.
Rankin, John, Structural Engineer, Deputy City Building Surveyor, Sydney, N. S. W., Australia
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Rapp, Paul, Room 151, Industrial Bldg., Bureau of Standards, Washington, D. C.
*Rasmussen, A. C. (See Insley Mfg. Co.)
Ratcliff, T. R., Union Station, Annex, Indianapolis, Ind.
Rath, H. F. (See Nickel Plate Sand & Gravel Co.)

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Raymond, Chas., University Tower Bldg., St. Catherine St. W. & University St., Montreal, Que., Canada
***Raymond Concrete Pile Co.,** 140 Cedar St., New York, N. Y. (H. P. Hamlin)
Raywid, Leo, 1608 K. St., N. W., Washington, D. C.
Read, Albert C. (See Los Angeles Public Library)
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Ready Mix and Supply Corp., P. O. Box 404, Albany, N. Y. (N. D. Crowley, Pres.)
Reagel, F. V. (See Missouri Highway Dept.)
Reaney, Charles F., 5341 Goodwin St., Dallas, Texas
Reaves, G. M., c/o St. Andrews' School, Middletown, Del.
Rebolledo, Miguel, 11a Artes 169, Mexico City, Mexico
Reed-Lewis, E. W. (See Super Cement (America) Co., Ltd.)
Reed-Lewis, W. J. D. (See The Super Cement Co.)
Reed Co., William T., 89 Broad St., Boston, Mass. (Wm. T. Reed)
Reed, Wm. T. (See William T. Reed Co.)
Regia Scuola D'Ingegneria, (Biblioteca) Torino, Italy
Regia Scula D'Ingegneria di Pisa, Torino, Italy (Prof. Giovanni Quaglia)
Reichard-Coulston, Inc., 95 Madison Ave., New York, N. Y. (W. A. Kennedy)
Reidy, Maurice A., 44 School St., Boston, Mass.
Reinhold, W. J., Equitable Life Bldg., Queen St., Brisbane, Australia
Reis, F. Santos, Barao Bom Retiro, 58, Rio de Janeiro, Brazil
Remler, R. F. (See The Grasselli Chemical Co., Inc.)
Remley, Norman W., Bureau of Bridges, Mo. State Highway Dept., Jefferson City, Mo.
Rengade, M. (See Ste. Amedes Chaux et Ciments de La Farge et du Teil)
Reniger Construction Co., 127 N. Cedar St., Lansing ,Mich. (M. H. Reniger)
Reniger, M. H. (See Reniger Construction Co.)
Rensaa, E. M., Room 460, Union Station, Winnipeg, Manitoba, Canada
Renwick, E. A. (See Holabird & Root)
Republic Fireproofing Co., Inc., 31 Union Square, New York, N. Y. (R. McWilliams)
Resseguie, H. D., Box 28, Bristol, N. H.
Reuter, Jr., Louis F. (See Paul Rieson's Sons Co.)
Revere, Giulo (See Laboratorio Prove Materiali)
Reynolds, C. E. (See Toronto Ready Mix Concrete Ltd.)
Reynolds, Frank L., 420 Lexington Ave., New York, N. Y.
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Rheinstein Construction Co., Inc., 21 E. 40th St., New York, N. Y. (A. Rheinstein, Pres.)
Rheinstein, A. (See Rheinstein Construction Co., Inc.)
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Rhines, Geo. V., Mills, Rhines, Bellman & Nordhoff, 1234 Ohio Bldg., Toledo, Ohio
Rhode, Howard (See International Cement Corp.)
Rhodes, Geo. I. (See Ford, Bacon & Davis, Inc.)
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Rhodes, J. Norton, P. O. Box 776, Freeport, Texas
Rib-Stone Concrete Corp., LeRoy, N. Y. (George E. Priest, Pres. & Treas.)
Rich, B. A. (See Monks & Johnson)
Rice, E. W. (See Santa Cruz Portland Cement Co.)
Rice, John A., 805 Santa Barbara Rd., Berkeley, Calif.
Richard, N. A., V. P., Purdy & Henderson Co., 45 East 17th St., New York, N. Y.
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Rickey, James W. (See Aluminum Company of America)
Rickter, Jean Paul (See The Ballinger Co.)
Ridge, R. S., 1316 Olive St., Philadelphia Pa.
Riehle Bros. Testing Machine Co., 1424 North 9th St., Philadelphia, Pa. (W. C. Moran)
Rieson's Sons Co., Paul, 2660 N. Humboldt Ave., Milwaukee, Wis. (Louis F. Reuter, Jr.)
Riis, Erling (See Southern Kraft Corp.)
Riley, Harbord & Law, 16 Victoria St., Westminster, London, England (E. W. Palmer)
Ringers, J. A., Koninginnegracht 52, Den Haag, Holland
Rishel, Jno. (See Ira C. Wilcox, Inc.)
Rich, Melvin S., 1427 Eye Street, N. W., Washington, D. C.
Ritter, Louis E., 140 So. Dearborn St., Chicago, Ill.
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Ritterbush, Robert A. (See Ritterbush Bros.)
***Riverside Cement Co.,** 621 S. Hope St., Los Angeles, Calif. (R. C. Aussieker)
Riverton Lime Co., Riverton, Va. (G. W. Hutchinson)
Rivet-Grip Steel Co., The 2404 Prospect Ave., Cleveland, Ohio (H. A. Stuart)
Roach, M. J., Turner Constr. Co., 420 Lexington Ave., New York, N. Y.
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Robb, L. A. (See Ambursen Construction Co., Ltd.)
Robb, R. E., General Motors Inst. of Technology, Chevrolet & 3rd Aves., Flint, Mich.
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Roberts, F. K., Public Works Dept., Karamea, New Zealand
Roberts, Hayden, (See Holliburton Oil Well Cementing Co.)
Roberts, H. W., The Hotel Duncan, 1151 Chapel St., New Haven, Conn.
Roberts & Schaefer Co., 1110 Wrigley Bldg., Chicago, Ill. (E. E. Barrett, Pres.)
Roberts, Warren T. (See Abel Construction Co.)
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Robertson, R. D. (See Independent Concrete Pipe Co.)

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Robeson, Harold B., Nazareth Cement Co., Nazareth, Pa.
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Robbins, Henry C. (See Densmore LeClear & Robbins)
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Robinson, G. G. (See Standard Paving & Materials Ltd.)
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Rockwood, Nathan C. (See Rock Products)
Rodes, A. B. (See Franklin Limestone Co.)
Rogers, Eben, c/o Alton Brick Co., Alton, Ill.
Rodrigvez, Lvis M., 19 Y L Num. 172, Vedado, Havana, Cuba
Roemer, Edw. W. (See Boston Building Dept.)
*Roeth, A. C. (See Inland Steel Co.)
Rogan, W. B., 1857 East 82nd St., Cleveland, Ohio
Rogers Co., J. S., 859 Drexel Bldg., Philadelphia, Pa. (J. Clyde Rogers)
Rogers, J. Clyde (See J. S. Rogers Co.)
Rolfsen, O., Notodden, Norway
Rooney, Geo. T. (See The Scully Co.)
***Roos Co., H. W.,** Cincinnati, Ohio (H. W. Roos, Pres.)
*Roos, H. W. (See H. W. Roos Co.)
Roos Co., The H. W., 2036-46 Dana Ave., Cincinnati, Ohio (H. W. Roos, Pres. & Treas.)
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Rowland, Walter, c/o Atmospheric Nitrogen Corp., Hopewell, Va.
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Ryan, Joseph J. (See Ryan Ready Mixed Concrete Corp.)
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Rylander, Paul N., V. P. Macdonald Spencer Engineering Co., 420 Lexington Ave., New York, N. Y.
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Ste. Amedes Chaux et Ciments de La Farge et du Teil, La Teil, Ardeche, France (M. Rengade)
St. Joseph Cinder Block Co., St. Joseph, Mo. (Robert Brown)
St. Louis Concrete Products Mfg. Co., 957 North & South Rd., Brentwood, Mo. (Frank J. Grutsch)
St. Louis Duntile Co., Route No. 5, Webster Groves, Mo. (Joseph Amend, Secy.)
St. Louis Material & Supply Co., 314 N. 4th St., St. Louis, Mo. (Otto S. Conrades)
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Sanderson & Porter, 52 William St., New York City
Sandstone Quarries Co., The, 20 Groveland Ave., Minneapolis, Minn. (C. D. Lynds)
Sanford, L. M., 400 Hiram Sibley Bldg., Rochester, N. Y.
San Joaquin Light & Power Corp., Fresno, Calif. (J. M. Buswell)
San Juan, Department of the Interior, San Juan, Porto Rico) Guillermo Esteves)
Santa Cruz Portland Cement Co., Davenport, Calif. (E. W. Rice)
***Santa Cruz Portland Cement Co.,** Crocker Bldg., San Francisco, Calif. (George R. Gay
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Sargent & Lundy, Inc., 20 N. Wacker Drive, Chicago, Ill. (J. C. Sanderson)
Sarwar, M. G., Punjab P. W. D., Hydro Electric Branch, P. O. Barot, via Jogindar Nagar, (Mandi State) India

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Scheidenhelm, Edward L. (See Edward L. Scheidenhelm Co.)
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Schmidt, T. J. (See Standard Art Stone Co.)
Schmitt, Eugene H. (See H. Schmitt & Son Inc.)
Schmitt & Son Inc., H., 930 E. Burleigh St., Milwaukee, Wis. (Eugene H. Schmitt)
Schmitz, N. J. (See C. B. Fritz Co.)
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Schrank, Charles (See Eagle Chemical Co.)
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Scott, Paul E. (See Stone Brick & Block Works, Inc.)
Scott, J. R., Weland, Ont., Canada
Scott, W. M. (See Greater Winnipeg Water District)
*Scott, W. W. (See Laclede Steel Co.)
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Senior, John L. (See Consolidated Cement Corp.)
Sensing, W. C. (See Wilson-Weesner-Wilkinson Co.)
Seron, Levon, 11 Inman St., Cambridge, Mass.
Servey, Dan F. (See The Haydite Co.)
Setna, J. N., c/o Messrs. Thomas Cook & Sons, Bombay, India
Severin Co., N. P., 222 W. Adams St., Chicago, Ill. (B. J. Myren)
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Shank, J. R., Engineering Exp. Station, Ohio State University, Columbus, Ohio
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Sharman, Basil C. (See John Ellis & Sons, Ltd.)
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Shedd, George G. (See L. H. Shattuck, Inc.)

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Shelverton, W. L., Washington, Ga.
Shenk, A. B. (See Federal American Cement Tile Co.)
Shenk, A. M. (See McEverlast, Inc.)
Shenk, E. R. (See Henry Shenk Co.)
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Simpson, Jr., Alex. (See Alex. Simpson, Jr., Co.)
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Simpson, W. E. (See W. E. Simpson Co.)
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Singleton-Green, J., Highfield House, Rosina St. Higher Openshaw, Manchester, England
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Sleight, T. R., Toledo Concrete Pipe Co., Silica, Ohio
Smaill, Wm. (See Northern Construction Co., Ltd.)
Small, A. R. (See Underwriters' Laboratories)
Small, H. W. (See Arnold Construction Co.)
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Smith, Blaine S. (See Pennsylvania Dixie Cement Corp.
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Soga, Susumu, c/o The Okura Doboku Kabushikikaishia, Ginza Tokyo, Japan
Soc. Porcheddu Ing. G. A., Cors Valentino 20, Torino, Italy, (G. A. Porcheddu)
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South Carolina Highway Dept., Columbia, S. C. (W. H. Mills, Jr., Test. Engr.)
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Southern California Edison Co., Edison Bldg., Los Angeles, Calif.
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Southern Kraft Corp., Panama City, Pa. (Erling Riis, Chief Engr.)
Southwestern Engineering Co., 306 McDaniel Bldg., Springfield, Mo. (L. D. Rosenbauer)
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Standards Association of Australia, Science House, Gloucester & Essex Sts., Sydney, N. S. W., Australia (W. R. Hebblewhite, Gen. Sec.)
Standard Clay Products Ltd., St. Johns, Quebec, Canada (C. T. Trotter)
Standard Concrete Pipe & Curbing Co., 701 S. Tonti St., New Orleans, La.
Standard Gravel Co., New Hudson, Mich. (O. E. Gooding)
Standard Inspection Co., 119 Federal St., Pittsburgh, Pa. (John M. Bailey)
Standard Oil Company, Library, 225 Bush St., San Francisco, Calif. (Margaret Hatch, Librarian)
Standard Oil Development Co., (Rayway) P. O. Box 37, Elizabeth, N. J. (Chas. E. Haupt)
Standard Paving & Materials Ltd., 402 Harbor Bldg., Toronto, Ont., Canada (G. G. Robinson)
Standard Portland Cement Co., P. O. Box G, Painesville, Ohio (Erie J. Ochs, Supt.)
Standard Slag Co., Youngstown, O. (F. E. Miller, Sales Mgr.)
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Starrett Brothers & Eken, Inc., 101 Park Ave., New York, N. Y. (Russell H. Hunter)
Stauffer, P. F. (See Fuller Co.)
Steele, Byram W., 440 Custom House, Denver, Colo.
*Steele & Sons Co., Wm., 124 No. 15th St., Philadelphia, Pa.
Steele & Sons Co., Wm., 124 No. 15th St., Philadelphia, Pa.
Steiner, Angelo, S. Giovanni in Fiore, Cosenza, Italy
Steiner, W. H., 1001 Hubbel Bldg., Des Moines, Iowa
Steinman, D. B., 117 Liberty St., New York, N. Y.
Stelley, Harry A., Foot of Hertel Ave., Buffalo, N. Y.
Steimer, William A., 40 Windsor Rd., Cranston, R. I.
Steljes, Martin, 105 Hill St., New Rochelle, N. Y.
Stepanian, S. (See The Arrow Sand & Gravel Co.)
Stephens, A. W., 369 Lexington Ave., New York, N. Y.
Stephens, Carroll, Golden Gate Atlas Materials Co., 16th & Harrison St., San Francisco, Calif.
Stephenson, L. E., 507 West 113th St., New York, N. Y.
Stern, Eugene W., 56 West 45th St., New York, N. Y.
Stern, I. F., 38 So. Dearborn St., Chicago, Ill.
Stetson, F. M., 719 Franklin Ave., Aliquippa, Pa.
Steuding, Paul H. (See Northwest Steel Rolling Mills, Inc.)
Stevens, Charles H., 1410 City Hall Annex, Philadelphia, Pa.
Stevens & Wood, Jackson, Mich. (Edw. M. Burd)
Stevens & Wood, Inc., 60 John St., New York, N. Y. (F. E. Murphy)
Stevenson, J. H., 4457 Stuart Bldg., Seattle, Wash.
Stewart, G. M., Engineering Dept., C. N. Rys., 429 New Union Station, Toronto, Ont., Canada
Stewart & Co., Inc., James, 17 E. 42nd St., New York City (H. W. Lohmann, Vice-Pres.)
Stewart, Frank G., 1520 Locust St., Philadelphia, Pa.
Stewart, J. H. (See Milburn Lime & Cement Co.)
Stewart, L. C. (See the Dow Chemical Co.)
Stewart, Wm. J., 105 Baker St., London, W. I., England
Stiefel, Alfred C., 1578 Jackson St., Denver, Colo.
Stierlen, Wilhelm, Gotenring 37, Cologne, Germany
Stiff, C. K. (See Assoc. Factory Mutual Fire Insurance Cos.)
Stineman, Norman M. (See Concrete Publishing Co.)
Stoddard, A. E., 427 Ash St., Ames, Iowa
Stoddard, Ralph P., 2121 Guarantee Title Bldg., Cleveland, Ohio
Stokes, G. W., Matthews & Mumby Ltd., 129 Stockport Rd., Ardwick, Manchester, Eng.
Stone Brick & Block Works, Inc., 111 East 63rd St., Chicago, Ill. (Paul E. Scott, Pres.)
Stone, G. M. & G. C., P. O. Box 612, Bristol, Va.
Stone, O. O., Dime Bank Bldg., Detroit, Mich.
*Stone & Webster, 49 Federal St., Boston, Mass. (C. E. Nichols)
Stoneham, Herbert (See American Sika Corp.)
Stotz, Jr., Edward, 801 Bessemer Bldg., Pittsburgh, Pa.
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Stradling, R. E., Building Research Station, Bucknalls Lane, Garston, Herts, England
*Straub, F. J., Elizabeth St., New Kensington, Pa.
Straub, Dr. Lorenz G., Experimental Engrg. Bldg., University of Minnesota, Minneapolis, Minn.
Strauss, Joseph B., 307 No. Michigan Ave., Chicago, Ill.
Strawbridge, E. T. (See Western Brick Co.)

Street, L. J. (See The National Testing Laboratories, Ltd.)
Strohm, Adam (See Detroit Public Library)
Struckmann, Holger, c/o International Cement Corp., 342 Madison Ave., New York City
Struthers, O. C., 1307 Washington Bldg., Los Angeles, Calif.
Stuart, Francis Lee, 949 Broadway, New York, N. Y.
Stuart's Granolithic Co., Ltd., 62 Lincoln's Inn Fields, London, W. C. 2, England (Wm. Adams, Managing Director)
Stuart, H. A. (See The Rivet-Grip Steel Co.)
Stuart, J. H., Stuart Vault Works, Bremen, Ohio
Stuart, Percy R. (See Calif. Stucco Products Co. of N. C.)
Suckow, V. C., 437 Central Bldg., Seattle, Wash.
Suhr, Berryman Peterson & Suhr, Inc., 130 N. Wells St., Chicago, Ill. (Ivan C. Peterson)
Suits, A. C. (See Art Stone Co.,)
Sullivan, F. Daly, Pres., The Sullivan Co., 708 Union & Planters Bk. Bldg., Memphis, Tenn.
Sullivan, P. L., Escanaba, Mich.
Summers, R. E. J., Pres., Summers Engineering & Constructors, Inc., Terminal Tower Bldg., Cleveland, Ohio
Sundstrom, C. A., 25 9th St., New York City
Super Cement (America) Co., Ltd., 863 Bay St., Toronto, Ontario, Canada (E. W. Reed-Lewis)
Super Concrete Emulsions, Ltd., 3710 So. Alameda St., Los Angeles, Calif. (C. E. Little)
Superior Portland Cement Co., Concrete, Wash. (C. L. Wagner, Supt.)
***Superior Portland Cement Co.,** Seaboard Bldg., Seattle, Wash. (E. P. Lucas)
Super Cement Co., The, 1754 Buhl Bldg., Detroit, Mich. (W. J. D. Reed-Lewis)
Sureseal Manufacturing Co., 297 Ocean St., Jersey City, N. J. (Walter J. Gorman, Pres.)
Surveyer, Arthur, 1003 Dominion Square Bldg., Montreal, P. Q., Canada
Suter, Oscar M., La Ceiba, Spanish Honduras, Central America
Sutherland, Hale, Lehigh University, Bethlehem, Pa.
Sutherland, John D., Town Hall, Melbourne, Australia
Suzuki, Hajime, c/o Ohbayashi-Gumi, Ltd., No. 2, 1-Chome, Marunouchi, Kojimachi-ku, Tokyo, Japan
Svenska Betongforeningen, c/o Rikard V. Frost, S:t Eriksgatan 88, Stockholm, Sweden
Svenska Cementforeningen, u. p. a., Kungsgaten 35, Stockholm, Sweden (Tage Bilde)
Swain, George F., Harvard University, Cambridge, Mass.
Swanson, A. G., 28th Ave. & Sahler St., Omaha, Nebr.
Swanson, C. E., 4531 Summit St., Kansas City, Mo.
Swanson, Inc., G. Fred, 87 Waybosset St., Providence, R. I. (G. Fred Swanson, Pres. & Treas.)
Swanson, G. Fred (See G. Fred Swanson, Inc.)
Swartz, Leo (See Olympian Stone Co.)
Sweetser, Ernest O., Washington University, St. Louis, Mo.
Sylliaasen, M. O., 4550 Thackeray Place, Seattle, Wash.
Taege, Paul C. (See Arlington Concrete Products Co.
Taggart, A. D., Cement City, Mich.
Talbot, Arthur N., 1113 W. California Ave., Urbana, Ill.
Talbot, Kenneth H., Director of Research, National Equipment Corp., 31st & Concordia Ave., Milwaukee, Wis.
Tappan, K. H., c/o Alcoa Power Co. Ltd., Kenogami, Que., Canada
Tatnall, Francis G., Southwark Foundry & Machine Co., 400 Washington Ave., Philadelphia, Pa.
Taylor, A. J. (See Hill & Taylor)
Taylor, Dean T. U. (See University of Texas)
Taylor & Co., Richard, 331 Collins St., Melbourne, Victoria, Australia (Frank J. Hannan)
Taylor, S. V. (See Concrete Steel Fireproofing Co.
Teaze, Moses Hay, 31 Clarendon Place, Bloomfield, N. J.
Technische Hoogeschool, Oostplantsoen, Delft, Holland (J. A. Bakker)
Teknisk Bibliotek, Polytecknisk Laereanstalt, Kopenhagen K, Denmark (Helge Holst, Librarian)
Teich, Ralph A. (See H. A. Dailey Contracting Co.)
Telles, Francisco T. de Silva, Caixa Postal 2982, Sao Paulo, Brazil
Terrell, D. V., University of Kentucky, Lexington, Ky.
Tetsall, E. P., Mason's Portland Cement Co., Ltd., Claydon, Ipswich, England
Texas Engineering Experiment St., College Station, Texas (F. F. Giesecke, Director)
Texas, University of, Dept. of Civil Engineering, Austin, Texas (Dean T. U. Taylor)
Texas, University of, Engineering Experiment Station, Box L, University Station, Austin, Texas (Raymond F. Dawson)
Texas Technological College, Civil Engineering Dept., Lubbock, Texas (J. H. Murdough)
Thacker, G. W., 1401 Hawthorne Terrace, Berkeley, Calif.
Thee, T. C., 864 Saunders Kennedy Bldg., Omaha, Nebr.
Thomas, A. Rylands, Nasik Irrigation Division, Nasik, Bombay Pres. India
Thomas, Earl C., Room 269, Engineering Bldg., Stanford University, Calif.
Thomas Cast Stone Co., Ernest, 841 Pacific St., Portland, Oregon (Ernest Thomas, Pres.)
Thomas, Ernest (See Ernest Thomas Cast Stone Co.)
Thomas, Frederick G., c/o The Reinforcing Steel Co. Ltd., P. O. Box 117, Salisbury Rhodesia, South Africa
Thomas, Harry E., P. G. & E. Laboratory, 4245 Hollis St., Emeryville, Calif.
Thomas & Sons Co., The R., Lisbon, Ohio (H. P. Sleeman)
Thompson & Binger, 565 Fifth Ave., New York, N. Y. (W. D. Binger)
Thompson, Carroll R., Dept. Wharves, Docks, Ferries, Chestnut St. Pier, Philadelphia, Pa.
Thompson, Dewey (See H. C. Nutting Co. of N. J.)
Thompson, G. Saxton, 1549 Lee Road, Cleveland Heights, Ohio
Thompson, James, 140 Cedar St., New York, N. Y.
Thompson, John H., Sterling Road, Fenimore Park, Harrison, N. Y.
Thompson-Lichtner Co. Inc., Statler Bldg., Boston, Mass. (Miles N. Clair)
Thompson-Lichtner Co., Inc., Statler Bldg., Boston, Mass. (Sanford E. Thompson)
Thompson, R. M., Imperial Bk. Bldg., Sandwich, Ont., Canada
Thompson, S. E. (See Thompson Lichtner Co.)
*Thompson, Scott (See Lone Star Cement Co.)

*Thompson-Starrett Co., 250 Park Ave., New York, N. Y.
Thompson, Warren H., 616 Stock Exchange Bldg., Buffalo, N. Y.
Thompson, W. N., c/o H. K. Ferguson Co., Hanna Bldg., Cleveland, O.
Thomson, Duncan, Onondaga Litholite Co., 102 N. Beech St., Syracuse, N. Y.
Thomson, Gordon, Experimental Engineering, University of Minnesota, Minneapolis, Minn.
Thomson, H. F. (See General Material Co.)
Thorn, Jr., Frederick G., The Philadelphia Gas Works Co., 1401 Arch St., Philadelphia, Pa.
Thorvaldson, T., University of Saskatchewan, Saskatoon, Canada
Thropp, Douglas S. (See Waterside Concrete Works)
Thurston Co., Inc., W. P., P. O. Box 2089, Richmond, Va. (W. P. Thurston)
Thurston, W. P. (See W. P. Thurston Co., Inc.)
Tibbetts, Sydney A., 1613 Josephine St., Berkeley, Calif.
Tillson, H. L. (See American Vibrolithic Corp.)
Timanus, C. S. (See Burns & McDonnell Engineering Co.)
Timberman, W. J. (See Nassau Sand & Gravel Co.)
Timlin, M. A., E. L. Conwell & Co., 2024 Arch St., Philadelphia, Pa.
Tinkler, J. W., 315 Snowden Ave., Bedford Park, Toronto, Ont., Canada
Toch Bros. Inc., 386 Fourth Ave., New York, N. Y. (Maximilian Toch)
*Toch Brothers, Inc., 386 Fourth Ave., New York City (Maximilian Toch, Vice-Pres.)
*Toch, Maximillian (See Toch Brothers, Inc.)
Toledo Concrete Pipe Co., P. O. Box 835, Toledo, Ohio (L. J. Loughlin)
Tomita, M., c/o Materials Testing Laboratory, University of Illinois, Urbana, Ill.
Tomes, P. Austen, 101 Park Ave., New York, N. Y.
Tompkins, Charles H., 1608 K St., N. W., Washington, D. C.
*Tomlin, Edwin (See British Columbia Cement Co.)
Toner, A. C., District Engineer, Portland Cement Assn., 925 National Press Bldg., Washington, D. C.
Toronto Ready Mix Concrete Ltd., Room 1017 159 Bay St., Toronto, Ont., Canada (C. E. Reynolds)
Torres, Ary F., Escola Polytechnica, Sao Paulo, Brazil
Torrey, James E., 652 E. 26th St., Paterson, N. J.
Totti, Etienne, Box 634, San Juan, Porto Rico
Towles, Thomas Thomson, 49 Federal St., Boston, Mass.
Tozzer, Arthur C., 420 Lexington Ave., New York, N. Y.
Trainor, Lee S., Ch. Engr. Construction Dept., National Lime Association, 927 15th St., N. W., Washington, D. C.
Transit Mixers, Inc., 430 Call Bldg., San Francisco, Calif (E. T. Tuller, V. P.)
Traver Supply Co., W. G., 1902 N. Water St., Decatur, Ill. (W. G. Traver)
Traver, W. G. (See W. G. Traver Supply Co.)
Treanor, John, c/o Riverside Cement Co., 621 S. Hope St., Los Angeles, Calif.
Tremper, Bailey (See Washington State Highway Dept.)
Trickel, J. W. (See Aldrich Construction Co.)
Tripp, J. G., 605 Clara St., St. Louis, Mo.
Trost, A. G., Trost & Trost, Two Republics Bldg., El Paso, Texas
Trotter, C. T. (See Standard Clay Products Ltd.)
Troxell, G. E., Asst. Prof. of Civil Engineering, University of California, Berkeley, Calif.
Trueblood, Paul M., 1812 Nob Hill Ave., Seattle, Wash.
Trueblood, Wilford S., 215 West 7th St., Los Angeles, Calif.
Trufant, Russell A., 10 Roch St., Middleborough, Mass.
Trussed Concrete Steel Co. of Canada, Ltd., Walkerville, Ont., Canada (E. G. Ryley, Chief Engr.)
Truscon Laboratories, The, Caniff & Grand Trunk R. R., Detroit, Mich. (R. A. Plumb)
*Truscon Steel Co., Youngstown, Ohio (Julius Kahn, Pres.)
Tubesing, William F., 708 Oakland Ave., Milwaukee, Wis.
Tucker, Gilbert E. (See The Pacific Stone Co.)
Tucker, Jr., John, 5403 39th St. N. W., Washington, D. C.
Tucker, Ross F., Mass. Institute of Technology, Cambridge, Mass.
Tuller, E. T. (See Transit Mixers, Inc.)
Turner, C. A. P., 300 Bldrs. Exchange Bldg., Minneapolis, Minn.
*Turner Construction Co., 775 Main St., Buffalo, N. Y. (H. A. Ward)
*Turner Construction Co., 420 Lexington Ave., New York, N. Y. (E. J. Moore)
*Turner Construction Co., 420 Lexington Ave., New York, N. Y. (H. C. Turner)
*Turner Construction Co., Architects' Building, Philadelphia, Pa. (J. A. Turner)
Turner, Frank C., Dept. of Applied Science, Sheffield, England
Turner, G. C. (See Concrete Marble Co.)
Turner, Jr., Henry C., c/o Turner Construction Co., 420 Lexington Ave., New York, N. Y.
*Turner, H. C. (See Turner Const. Co.)
*Turner, J. A. (See Turner Const. Co.)
Turner, J. M., c/o Raymond Concrete Pile Co., 31 St. James Ave., Boston, Mass.
Turner & Sons, John P., Amsterdam, N. Y.
Turquais, F. (See Societe des Ciments Francais)
Tuthill, Lewis H., 755 Mallory St., Los Angeles, Calif.
Twine, G. T., Queensland Cement & Lime Co. Ltd., 129 Creek St., Brisbane, Australia
Twining, F. E., P. O. Box 1320, Fresno, Calif.
Tyler, F. E. (See Dewey Portland Cement Co.)
Uchimura, Sabro, 37 Nozawa, Komazawa-Mura, Ibara-Gum, Tokyo-Fu, Japan
Uhr, Saul, 1028 W. Wyoming Ave., Philadelphia, Pa.
Uhrich, M. J., 712 3rd St. West, Seattle, Wash.
Ulman, Malcolm H., 1118 State St., Harrisburg, Pa.
Ulrich, Thomas J., 78 Sterling St., East Orange, N. J.
Underhill, P. H., Stone & Webster, 49 Federal St., Boston, Mass.
Underwriters' Laboratories, 109 Leonard St., New York, N. Y. (A. R. Small)
Union College, C. E. Dept., Schenectady, N. Y. (Prof. Henry A. Schauffler)
Union Pacific System, 1416 Dodge St., Omaha, Nebr. (H. C. Mann)
*United Engineers & Constructors Inc., 112 North Broad St., Philadelphia, Pa. (Prof. F. O. Dufour)
Universal Atlas Cement Co., 632 Brown Marx Bldg., Birmingham, Ala. (J. C. Meacham)

*__Universal Atlas Cement Co.__, Chrysler Bldg., 135 East 42nd St., New York, N. Y. (E. K. Borchard)
*__Universal Atlas Cement Co.__, Chrysler Bldg., 135 East 42nd St., New York, N. Y. (C. R. Hulsart)
*__Universal Atlas Cement Co.__, 210 So. LaSalle St., Chicago, Ill.
*__Universal Atlas Cement Co.__, 210 So. LaSalle St., Chicago, Ill. (B. F. Affleck, Pres.)
__Upham, Chas. M.__, Highway Engineering Bureau, National Press Bldg., Washington, D. C.
__Upson, Maxwell M.__, 140 Cedar St., New York, N. Y.
Upton, L. (See Bound Brook Crushed Stone Co.)
Upton, T. H. (See N. S. W. Main Roads Board)
__Urner, J. P.__, Scott & Urner Ltd., Barao Itapetininga 37A, Sao Paulo, Brazil
__Urquhart, L. C.__, School of Civil Engineering, Cornell University, Ithaca, N. Y.
__Usilton, L. H.__, c/o DiMarco & Reimann, 199 St. & Jerome Ave., Bronx, N. Y.
__Vago, Oscar J.__, 2281 37th St., Long Island City, N. Y.
__Valentine Lumber & Supply Co.__, 102 Albany St., Springfield, Mass. (Frank J. Murphy)
Vallee, Ivan E. (See Quebec Dept. of Public Works)
__Valle, Juan Augustin,__ Calle Galileo 2416, Buenos Aires, Arg.
__Van Asdlen Construction Co.__, 1600 Arch St., Philadelphia, Pa. (W. S. Van Asdlen)
Van Asdlen, W. S. (See Van Asdlen Construction Co.)
__Van Buren, Maurice P.__, 125 East 50th St., New York, N. Y.
__Van Camp Stone Co.__, 405 Palace Theatre Bldg., Cincinnati, Ohio (J. J. Liggett)
__Van Eenam, Neil,__ Mich. State Highway Dept., 224 N. Jenison Ave., Lansing, Mich.
__Vanderlip, A. N.,__ 202 University Ave., Ithaca, N. Y.
__Vandever, Jacob B.,__ 41 E. 42nd St., New York, N. Y.
__Vandone, Italo,__ Via Luigi Mangiagalli No. 14, Milan, Italy
VanDervoort, Jameson (See Lee, Smith & Van Dervoort)
__Van Houten, Chas.,__ 4536 Wentworth Ave., Chicago, Ill.
__Van Name, R. L.,__ Pittsburgh Testing Laboratory, 72 Washington St., New York, N. Y.
Van Ness, F. H. (See American Vault Co.)
Van Ortroy, F. (See Cimenteries et Briquetaries Reunies C. B. R.)
__Van Raalte, S.,__ Horwood & White, 229 Yonge St., Toronto, Ont., Canada
__Van Scoyoc, H. S.,__ c/o Canada Cmt. Co., Ltd., Montreal, Quebec, Canada
*Van Scoyoc, H. S. (See Canada Cement Co., Ltd.)
__Van Trump, Isaac,__ 2327 S. Paulina St., Chicago, Ill.
__Vaso Mfg. Co.,__ 519 Central Blvd., Seattle, Wash. (Carl L. Leon, Mgr.)
__Vauclain, Jacques L.,__ Buck Lane, Bryn Mawr, Pa.
Veatch, Jr., N. T. (See Black & Veatch)
__Vegeler, W. F.,__ 708 Bakewell Bldg., Pittsburgh, Pa.
__Verein Deutscher Portland-Cement-Fabrikanten (E. V.),__ Hover, Hannover 1, Land, Germany (Dr. Rudolf Kneisel)
__Verey, H. G.,__ Woollahra Municipal Council, Ocean St., Woollahra, N. S. W., Australia
__Verschleiser, J. H.,__ c/o Laclede Steel Co., 1317 Arcade Bldg., St. Louis, Mo.
__Verity, Fred L.,__ 2559 West 20th St., Oklahoma City, Okla.
__Viens, E.,__ Director, Laboratory for Testing Materials, Public Works Dept., Ottawa, Ont.
__Vieira, E. de Moraes,__ Caixa postal 70, Campos Est., Rio de Janeiro, Brazil, S. A.
Vigliani, Carlo, (See "Italcementi")
__Vigorose Cement Industrie, N. V.,__ de Steeg, Holland (B. A. Honig, Pro. Mgr.)
__Vila, Jose Antonio,__ Maximo Gomez 317, Havana, Cuba
__Villadsen, Jens M.,__ Villadsen Bros., Inc., 417 Market St., San Francisco, Calif.
Villares, Arnaldo D. (See Severo & Villares)
Villeneuve, P. A. (See Caffiaux & Villeneuve)
__Vincent, R. A.,__ 517 St. Lawrence Blvd., Montreal, Que., Canada
Vivian, G. H. E. (See "La Tolteca" Cia. de Cemento Portland, S. A.)
__Vogel, John Leonard,__ P. O. Box 561, Manasquan, N. J.
__Vogel, John L.,__ Bridge Engr. D. L. & W. R. R. Company, Hoboken N. J.
__Vogt, R. C.,__ U. S. Engineer Office, Duluth, Minn.
__Voorhees, Gmelin & Walker,__ 101 Park Ave., New York City (Richard A. Backus)
__VorKeller, Albert,__ Melbourne, Fla.
__Voshell, James T.,__ South Chicago P. O. Bldg., Chicago, Ill.
__Voss, Walter C.,__ Old Town Road, Wellesley Farms, Mass.
__Votaw, Curtis H.,__ 212 S. Burns, Holdinville, Okla.
__Vulcanite Portland Cement Co.,__ 45th St. & Park Ave., New York City (Albert Moyer)
__Waasan Rautabetoni O. Y.,__ Vaasa, Finland (A. Lepisto)
__Waddington, C. V.,__ Kansas Gas & Electric Co., Wichita, Kans.
__Wadsworth, John Frederick,__ 818 Commerce Bldg., Erie, Pa.
Wagner, C. L. (See Superior Portland Cement Co.)
__Wagner, Samuel T.,__ School House Lane, Germantown, Philadelphia, Pa.
Wait, H. R. (See Monarch Engrg. Co.)
__Waite, H. M.,__ 1020 Temple Bar Bldg., Cincinnati, Ohio
__Waldo, Inc., E. M. & F.,__ Muirkirk, Md. (Edward M. Waldo, Pres.)
Waldo, Edward M. (See E. M. & F. Waldo, Inc.)
__Walker, C. G.,__ 33 W. Grand Ave., Chicago, Ill.
__Walker, Frank R.,__ 536 Lake Shore Drive, Chicago, Ill.
__Walker, Stanton,__ National Sand & Gravel Assn., Suite 545, Munsey Bldg., Washington, D. C.
__Wallace, Gordon L.,__ 68 Glenwood Ave., Toronto, Ont., Canada
__Wallace, Robert W.,__ 35 E. Wacker Dr., Chicago, Ill.
__Wallace, W. K.,__ London Midland & Scottish Railway Co., 20 Euston Square, London, N. W. 1, England
__Walsh, H. N.,__ University College, Cork, Ireland
__Walter, L. W.,__ 168 Provost St., Jersey City, N. J.
__Ward, A. A.,__ 415 E. State St., Ithaca, N. Y.
*Ward, H. A. (See Turner Construction Co.)
__Ward, Harry A.,__ 775 Main St., Buffalo, N. Y.
__Ward, Inc., J. F.,__ 509 Lyon Bldg., Seattle, Wash. (J. F. Ward)
Ward, J. F. (See J. F. Ward, Inc.)
__Ward, William B.,__ 800 Merchants Bank Bldg., Cincinnati, Ohio
__Warner Co.,__ 1616 Walnut St., Philadelphia, Pa.
Warner, Julius J. (See The Cincinnati Bldrs. Supply Co.)

Warnock & Co. Ltd., Chas., 402 McGill Bldg., Montreal, Que., Canada (Chas. Warnock)
Warnock, Chas. (See Chas. Warnock & Co. Ltd.)
Warren, Alexander C. (See Hoeffer & Co.)
Warren, Francis B., c/o Turner Construction Co., 420 Lexington Ave., New York, N. Y.
Warren Co., F. V., Lewis Tower, 15th & Locust Sts., Philadelphia, Pa. (F. V. Warren, Pres.)
Warren, F. V. (See F. V. Warren Co.)
Warren, George E., 33 West Grand Ave., Chicago, Ill
Warren, Ray V. (See Western Pennsylvania Sand & Gravel Assn.)
Washington State Highway Dept., Insurance Bldg., Olympia, Wash. (Bailey Tremper)
*Wason, L. C. (See Aberthaw Co.)
Wassef, K. Zaki,, Roads and Bridges Office, Beni-Suef, Egypt
Wasser, T. J., 25 Kensington Ave., Jersey City, N. J.
Wasson, J. H., Peerless Egyptian Cement Co., 1144 Free Press Bldg., Detroit, Mich.
Waterloo Concrete Corp., 1700 Water St., Waterloo, Iowa (C. L. Douthett, Pres.)
Waterman, Ivan F., 3333 Grant St., Corvallis, Ore.
Waterman, L. R., 1600 Peoria Life Bldg., Peoria, Ill.
Waterside Concrete Works, Commerce & Waterbury Ave., Bronx, N. Y. (Douglas S. Thropp, Gen. Mgr.)
Watkins, J. S. (See Kentucky State Highway Dept.)
Watkins, M. M., c/o N. O. Public Service Inc., 317 Baronne St., New Orleans, La.
Watson Company, P. O. Box 1002, Dallas, Texas (G. W. Andersen)
Watson, T. P., 115 Broad St. Station, Philadelphia, Pa.
Watson, W. J. (See Wilbur Watson & Associates)
Watson, W. P. (See The Hamilton Gravel Co.)
Watson & Associates, Wilbur, 4614 Prospect Ave., Cleveland, Ohio (W. J. Watson)
Watt, A. G., Young Bldg., Allentown, Pa.
Watt, Edwin L., 60 Wabun Ave., Providence, R. I.
Watts, Ivo S., Rooty Hill, N. S. W., Australia
Wausau Concrete Co., 211 Jefferson St., Wausau, Wis. (C. W. Parsons, Pres.)
Way, W. F., 2831 47th Ave., W., Seattle, Wash.
Weatherbee, L. B., c/o The Cooksville Co. Ltd., 26 Queen St. E., Toronto, Ont., Canada
Weathers, H. C. (See Florida State Road Dept.)
Weaver, H. A., 8843 Livernois Ave., Detroit, Mich.
Weaver, R. S. (See Allentown Portland Cement Co.)
Webb, Stafford, c/o Carolina Steel & Iron Co., Greensboro, N. C.
Webb, Walter Loring, 1001 Chestnut St., Philadelphia, Pa.
Weber, Walter R., 1534 Blake St., Denver, Colo.
Weber, Lester N., The Sisalkraft Co., Room 212-M, 205 W. Wacker Drive, Chicago, Ill.
Webster, Daniel T., Chief Engr., Marc Eidlitz Co., 41 East 42nd St., New York, N. Y.
Webster, J. E. (See Westinghouse Electric & Mfg. Co.)
Weeber, E. R. (See Hamilton & Weeber)
Weed, Lloyd W., 93 Trenton Ave., White Plains, N. Y.
Weerdt, H. E. de, 44 Salierring, Cologne, Germany
Wehtje, Jr., Ernst, Skanska Cement Aktiebolaget, Limhamn, Sweden
Weidman, H. P., Box 97, Chillicothe, Ill.
Weigel, Fred W. (See Southern Cement Products Co.)
Weiler, Charles B., c/o Gifford Wood Co., Hudson, N. Y.
Weir, C. Leslie, 13 East 37th St., New York City, N. Y.
Weismann, George F., 1014 Keystone Bldg., Houston, Texas
Weiss, Andrew, Estacion La Cruz, Chih., Mexico.
Weitz, Fred W., 713-15 Mulberry St., Des Moines, Iowa
Weldon, E., Iowa Falls, Ia.
Wells, Cyrus N. (See Florida Portland Cement Co.)
Wells, Hewitt, Woodward Bldg., Washington, D. C.
Wemmer, H. P., 5014 Marinda St., Omaha, Nebr.
Wendt, W. B. (See Speed Scientific School)
Wertz Co., The, 1033 Union Trust Bldg., Cleveland, Ohio (Louis S. Wertz, Pres.)
Wertz, Louis S. (See The Wertz Co.)
West, C. W., Welland Ship Canal, Thorold, Ont., Canada
West, J. R., Port Engineer, Port of Seattle, Seattle, Wash.
West Penn Cement Co., 233 S. Main St., Butler, Pa. (O. J. Binford)
Westchester County Park Commission, Bronxville, N. Y. (L. G. Holleran)
Westergaard, Harald M., 410 Delaware St. Urbana, Ill.
Western Brick Co., Danville, Ill (E. T. Strawbridge)
Western Pennsylvania Sand & Gravel Assn., 409 Empire Bldg., Pittsburgh, Pa. (Ray V. Warren)
Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa. (J. E. Webster)
Westinghouse Electric & Mfg. Co., Research Department, East Pittsburgh, Pa. (Dr. H. C. Harrison)
Wetstein, Mentor, 4669-71 Spring Grove Ave., Cincinnati, Ohio
Wetzel, E. H., c/o Nucarth Stone Co., Carthage, Mo.
Wheadon, Royston F., Riverside Dr. at 177th St., New York, N. Y.
Wheeler, Prof. W. H., Washington University, St. Louis, Mo.
Wheeler, Walter H., 1112 Metropolitan Life Bldg., Minneapolis, Minn.
Wheelock, D. L., 1621 5th St., Clay Center, Kans.
Wheelon, E. R., 514 West 105th St., Los Angeles, Calif.
Whelan, Frank R., 70 Claymoss Road, Brighton, Mass.
Whipple, Harvey, American Concrete Institute, 624 Fisher Bldg., Detroit, Mich.
Whitacre Engineering Co., Room 1617, 228 N. LaSalle St., Chicago, Ill. (Arthur Hagener)
Whitcraft, L. N., 347 Madison Ave., New York, N. Y.
White, Alfred H., 2028 E. Engineering Bldg., Ann Arbor, Mich.
White & Co., Barclay, 22 N. 36th St., Philadelphia, Pa. (Barclay White, Pres.)
White, Barclay (See White & Co., Barclay)
White, C. J., Exp. Engineering Bldg., University of Minnesota, Minneapolis, Minn.
***White Const. Co. Inc.**, 95 Madison Ave., New York, N. Y. (G. Ed. Escher, Pres.)
White, William E., 410 N. Michigan Ave., Chicago, Ill.
***Whitehall Cement Mfg. Co.**, 1736 Land Title Bldg., Philadelphia, Pa. (P. D. Gaskill)

Whitmore, L. S. (See Whitmore, Rauber & Vicinus)
Whitmore, Rauber & Vicinus, 51 Griffith Pt., Rochester, N. Y. (L. S. Whitmore, Vice-Pres.)
Whitney, Chas. S., 724 E. Mason St., Milwaukee, Wis.
Whitney, Gwin A. (See Whitney Materials Co.)
Whitney Materials Co., 403 W. Superior St., Duluth, Minn. (Gwin A. Whitney)
Wich, John F., 1154 Gorsuch Ave., Baltimore, Md.
Wicker, Carlton S. (See Buffalo Slag Co.)
Wickersham, John H., 53 N. Duke St., Lancaster, Pa.
Wiedemann, Ernest, (See Economy Concrete Company of Va., Inc.)
Wiepking, C. A., 1806 N. 52nd St., Milwaukee, Wisc.
Wig, R. J., 1102 Security Title Insurance Bldg., Los Angeles, Calif.
Wigton, C. B., 552 W. 23rd St., New York, N. Y.
Wilcox, Fred C., 626 Esplanade, Pelham Manor, N. Y.
Wilcox, Inc., Ira C., 6415 Hamilton Ave., Pittsburgh, Pa. (Jno. Rishel)
Wiles, J. R., 8 West 40th St., New York City
Wiley, A. J., 620 Idaho Bldg., Boise, Idaho
Wilk, Benjamin, 14250 Cloverdale Ave., Detroit, Mich.
Wilkes, Edmund (See Jones-Hettelsater Constr. Co.)
Will, Charles H., P. O. Box 856, Hilo, Hawaii
Willbee Concrete Products Co., 234 W. Euclid Ave., Jackson, Mich. (Charles E. Willbee)
Willbee, Charles E. (See Willbee Concrete Products Co.)
Williams, Chas. H., 826 Percival St., Olympia, Wash.
Williams & Co., C. K., Easton, Pa. (E. G. Davies, Vice-Pres.)
Williams, Chas. P., 4259 Witherby St., San Diego, Calif.
Williams, E. C., 150 W. Fourth St., Williamsport, Pa.
Williams, G. M., University of Saskatchewan, Saskatoon, Sask.
Williams, Jay T., 204 City Hall, Denver, Colo.
Williams, L. E., 3256 Carter Ave., Detroit, Mich.
Williams, M. A. (See Chicago Architectural Stone Co)
Williams, Robert L. (See Luzerne County Rd. & Bridge Dept.)
Williams, Timothy S., 3707 Hamilton St., Philadelphia, Pa.
Willingham-Little Stone Co., Atlanta, Ga. (H. S. Willingham, Pres.)
Willingham, H. S. (See Willingham-Little Stone Co.)
Willson, S. H., 902 Candler Bldg., Atlanta, Ga.
Wilner, E. R. (See Eddystone Cement Co.)
Wilshaw, P., 178 Pendrith St., Toronto 4, Ont., Canada
Wilsnack, George C. (See Edison Cement Co.)
Wilson, A. R., Room 670, Broad St. Sta., Philadelphia, Pa.
Wilson, C. B. (See Gould Contracting Co.)
Wilson, Francis F., 3 Wilson Lane, Rockville Center, L. I., New York
Wilson, Francis W., College House Offices, Harvard Sq., Cambridge, Mass.
Wilson, Joseph (See Burrell Engineering & Constr. Co.)
Wilson, Munsey (See Giesecke & Harris, Archts.)
Wilson, N. W., Jubilee House, Birmingham St., Kings Hill, Wednesbury, S. Staffs, England
Wilson's N. Z. Portland Cement Co., Box 269 G. P. O., Auckland, N. Z.
Wilson, Raymond, 33 West Grand Ave., Chicago, Ill.
Wilson & Co., R. F., 1859 Elston Ave., Chicago, Ill. (R. F. Wilson)
Wilson, R. F. (See R. F. Wilson & Co.)
Wilson-Weesner-Wilkinson Co., 108 Fatherland St., Nashville, Tenn. (W. C. Sensing)
Wimer, D. C., 608 Keystone Bldg., 4th Ave., Pittsburgh, Pa.
Winchester, Frank W., 10 Kunson Rd., Melrose, Mass.
Windes & Marsh, 598 Birch St., Winnetka, Ill. (Frank A. Windes)
Windes, Frank A. (See Windes & Marsh)
Windsor, A. S. (See The Cast Concrete Products Assn. Ltd.)
Windsor Cement Co. Inc., Box 1142, Hartford, Conn.
Winiger, Edward, 78 26th St., Jackson Heights, L. I., N. Y.
Winnetka, Village of, Village Hall, Winnetka, Ill. (Robt. L. Anderson, Bldg. Insp.)
Winokur, M. C., c/o Samuel M. Ash, 1901-105 West Madison St., Chicago, Ill.
Winslow Construction Co., 1700 Walnut St., Philadelphia, Pa. (John S. Krauss)
Winston Bros. Co., 520 Alaska Bldg., Seattle, Wash. (W. H. Gardiner)
Wisconsin University Library, Madison, Wis. (W. M. Smith)
Wiseman, W. J., 1942 Forbes St., Pittsburgh, Pa.
Withey, Morton Owen, 1921 West Lawn Ave., Madison, Wis.
Withrow, Roe E., 1200 Webb Road, Lakewood, Ohio
*Withrow, R. E. (See Medusa Portland Cement Co.)
Witmer, Francis P., University of Pennsylvania, Philadelphia, Pa.
Witt, J. C., 5834 Stony Island Ave., Chicago, Ill.
Witte, G. A. (See North American Cement Corp.)
Witte, Herman Calvert, 4626 Eastern Ave., Seattle, Wash.
Wolf, Robert D., 731 Ellicott Square, Buffalo, N. Y.
Wolfe, W. S., 800 Marquette Bldg., Detroit, Mich.
Wolpert, Otto, Box 2, Harmon, N. Y.
Wolverine Portland Cement Co., Coldwater, Mich.
Wood, David B., c/o Alcoa Power Co. Ltd., Kenogami, Que., Canada
Wood, Douglas, U. S. Bureau of Reclamation, Las Vegas, Nev.
Wood, J. D. (See Idaho Department of Public Works)
Wood, James, 150 W. 179th St., Bronx, N. Y.
Wood, J. V., 110 Spencer St., Melbourne, Vict., Australia
Wood L. H. (See Central Texas Iron Works)
Woodard, Silas H., 10 East 40th St., New York, N. Y.
Woodle, Jr., A. S., The Baldwin Locomotive Works, Philadelphia, Pa.
Woodruff, G. B., Overbrook Lane, Darien, Conn.
Woods, Hubert, c/o Riverside Cement Co., Riverside, Calif.
Woodstock Slag Corp., Southern Railway Bldg., Birmingham, Ala. (Geo. A. Mattison, Jr.)
Woody, C. C. (See Madison Silo Co.)
Worcester, J. R., 79 Milk St., Boston, Mass.

Worthen, A. L. (See The Connecticut Quarries Co. Inc.)
Wortman, Dietrich, 116 Lexington Ave., New York, N. Y.
Wright, A. H. W., Branch Mgr. & Engr., Palmerston, N., New Zealand
Wright, Chester C., 604 West 9th St., Austin, Texas
Wright, Harold B., 33 West Grand Ave., Chicago, Ill.
Wright & Kremers, Inc., Box 435, Niagara Falls, N. Y. (Ernest Kremers)
Wrzesien, Waclaw, ul. Nowowiejska 8 m 10, Warszawa, Poland
Wu, Pond S., c/o Chief Inspectorate of Salt Revenue, No. 18, The Bund, Shanghai, China
Wurster Construction Co., 307 Architects Bldg., Los Angeles, Calif. (V. L. Marsh, V. P.)
Wyeth-Scott Co., The, Manning St. & B. O. Railroad, Newark, Ohio (W. D. Wyeth, Pres.)
Wyatt, W. Kirk, Reading Terminal, Philadelphia, Pa.
Wyatt, Roy M. (See Horner & Wyatt)
Wyeth, W. D. (See The Wyeth-Scott Co.)
Yakima Cement Products Co., 611 No. Front St., Yakima, Wash. (W. P. Hews)
Yamashita, Toshirow, C. 12-6 Maruno-Uchi, Tokyo, Japan
Yandell & Conger, E. Lafayette St. and M. & O. R. R., Jackson, Tenn. (C. H. Yandell)
Yandell, C. H. (See Yandell & Conger)
Yeats, Alex J., 85 Farnham St., Belmont, Mass.
Yingling, Clinton K., 3000 Conn. Ave., Apt. 229, Washington, D. C.
Yosemite Portland Cement Corp., Drawer "W," Merced, Calif. (G. A. Fisher)
Young, Charles H., 600 Builders Exchange Bldg., Minneapolis, Minn.
Young, Clarence Richard, 98 Hilton Ave., Toronto, 10, Ontario
Young, Fred W., Box 46, Center Square, Pa.
Young, R. B., 8 Strachan Ave., Toronto, Ont.
Young, Roy N., Young Bldg., Allentown, Pa.
Young, W. J., Ch. Engr. The Standard Lime & Stone Co., P. O. Box 785, Martinsburg, W. Va.
Younghusband, V. G. (See The Foundation Co. of Canada Ltd.)
Youngstown Burial Vault Co., 546 Indianola Ave. E., Youngstown, Ohio (E. E. Kling, Mgr.)
Youngstown Sheet & Tube Co., The, East Chicago, Ind. (C. M. Bradley)
Ytterberg, C. F., 110 E. 42nd St., New York, N. Y.
Yu, M. T., Rue Verdun and Rue Takou, Tientsin, China
Zabriskie, W. F. (See Gabriel Steel Co.)
Zachry, H. B., Engineering & Constr. Co., Laredo, Texas
Zagoren, Louis I. (See The Goldsmith Metal Lath Co.)
Zass, W. W., c/o State Highway Commission, Little Rock, Ark.
Zaugg, F. R. (See Northwest Concrete Products Assn.)
Zehrlaut, H. A. R. (See Plastic Stone Products Corp.)
Zeidler, John L., 401 Francis St., St. Joseph, Mo.
Zeidler Concrete Products Mach. Co., Waterloo, Iowa (A. W. Schultz)
Zeiget, Jr., Conrad (See Baltimore Bureau of Standards)
Zipprodt, Roy R., 347 Madison Ave., New York, N. Y.

Geographical List — A. C. I. Membership

(For detailed addresses see Alphabetical List)

Alabama

Auburn—Barrow, A. C.
Birmingham — Alabama Concrete Pipe Co.
Birmingham Public Library. (Lila May Chapman, Director)
Birmingham Slag Co.
Cement Products Co. (G. L. Cox, Pres.)
Clark, W. B.
Connors Steel Co. (Geo. W. Connors)
*Ford, Bacon & Davis, Inc. (Geo. I. Rhodes, Vice-Pres.)
*Lone Star Cement Co. (J. W. Johnston)
Merrill, B. S.
Universal Atlas Cement Co. (J. C. Meacham)
Woodstock Slag Corp. (Geo. A. Mattison, Jr.)
Mobile—Converse & Co., J. B.
Muths, George A.
Montgomery — Houck, Howard H.
Tuskegee Inst.—Gibson, Jr., Chas. H.

Arizona

Phoenix — Arizona Highway Dept. (J. W. Powers)
Tucson—Headman, Sasha

Arkansas

Fayetteville—Spencer, W. R.
Little Rock—Lander, R. S.
Zass, W. W.
Magnolia—Hardy, A. W.

California

Alhambra — MacGlashan Associates, The (W. F. MacGlashan)
Azusa—Carlson, Roy W.
Berkeley — Davis, Harmer E.
Davis, Raymond E.
Rice, John A.
Thacker, G. Q.
Tibbets, Sydney A.
Troxell, G. E.
Claremont — Edwards, Harlan H.
Colton—*California Portland Cement Co. (W. C. Hanna, Chief Chemist)
Davenport — Santa Cruz Portland Cement Co. (E. W. Rice)
Emeryville — Macintyre, A. D.
Thomas, Harry E.
Fresno — Jourdan, Concrete Pipe Co. (H. W. Chutter)
McKenzie, A. H.
San Joaquin Light & Power Corp., Library. (J. M. Buswell)
Twining, F. E.
Gilroy—Beckwith, G. L.
Long Beach — Sherer, Horace C.
Los Angeles — Allen, George F.
Architecture and Allied Arts, Library of
Baruch Corp., Herbert M. (Herbert M. Baruch, Pres.)
Beckett, Garner A.
Bent Bros. (Arthur S. Bent)
Bent, Ernest F.
Binder, R. W.
Clay Products Institute of Calif.
Cline, L. A.
Eaton, E. C.
Emme, Frank E.
Jeffers, Paul E.
Los Angeles City Engineering Dept. (T. A. Fitch, Engr.)
Los Angeles Dept. of Water and Power. (E. F. Scattergood)
Los Angeles Public Library. (Albert C. Read)
Los Angeles Public Library. (Albert C. Read)
Los Angeles Testing Labratory. (H. H. McCall)
McEverlast, Inc. (A. M. Shenk, Pres.)
Materials, Inc. (E. C. Pohlman)
Meyer & Holler, Inc. (R. Howard Armin)
Noetzli, Fred A.
Noice, Blaine
Osborne, Raymond G.
Pacific Coast Talc Co. (Geo. Ames, Mgr.)
Phillips, Wm. B.
Potts, A. H.
Powell, F. H.
Quinton Code & Hill — Leeds & Barnard (Lou's C. Hill)
*Riverside Cement Co. (R. C. Aussieker)
Southern California Edison Co.
*Southwestern Portland Cement Co. (F. H. Powell)
Struthers, O. C.
Super Concrete Emulsions, Ltd. (C. E. Little)
Treanor, John
Trueblood, Wilford S.
Tuthill, Lewis H.
Wurster Construction Co. (V. L. Marsh, V. P.)
Wheelon, E. R.
Wig, R. J.
Wurster Construction Co. (V. L. Marsh, V. P.)
Merced—Yosemite Portland Cement Corp. (G. A. Fisher)
Monterey—Hoffman, R. B.
Oakland—Davis, A. P.
Dyer Construction Co., The (Kenneth W. Dyer)
Hanna, Frank W.
Howland, M. R.
Hutchinson, Jr., Hardye
Kaiser Paving Co. (T. M. Price)
Phillips, W. H.
Schorer, Herman
Pasadena — Beman, Willard J.
California Institute of Technology. (R. R. Martel, Assoc. Prof.)
Pasadena, City of
Pasadena Water Dept. (S. B. Morris)
Piedmont, Oakland — Hammill, Harold B.
Riverside — MacDonald, Earle
Woods, Hubert
Sacramento — State of California, Div. of Highways. (T. E. Stanton)
Hawley, Geo. W.
Perkins, Wayne A.
San Bernardino — Glen, Michael G.
San Diego—Jewett, John Y.
King, Thomas H.
Williams, Charles P.
San Francisco—Barrett & Hilp. (J. F. Barrett)
Brunnier, H. J.
Calif. Stucco Products Co. of N. C. (Percy R. Stuart)
Cowell Lime & Cement Co.
Day, W. P.
Denton, Arthur P.
Dewell, Henry D.
Dreyer, Walter
Ellison & Russell (W. H. Ellison)
Furlong, Irving
Grassi & Co., P. (P. Grassi)
Gunn, Charles M.
Hanks, Inc., Abbot A. (Theo. P. Dresser, Jr., Chief Engr.)
Harding, Carroll R.
Huber, Walter L.
Jellick, J. E.
Jorgenson, Lars
Kennoy, John S.
Leonard, John B.
McKesson, Claude L.

Nishkian, L. H.
*Santa Cruz Portland Cement Co. (George R. Gay)
Saph, Augustus V.
Soule Steel Co. (Edward L. Soule)
Spaulding, Horace R.
Standard Oil Co. Library. (Margaret Hatch, Librarian)
Stephens, Carroll
Transit Mixers, Inc. (E. T. Tuller, Vice-Pres.)
Villadsen, Jens. M.
San Marino — Kressly, Paul E.
San Mateo—Deuel, A. W.
Santa Monica—Collings Co., W. A. (W. A. Collings, Mgr.)
San Simeon—Hayden, J. M.
Stanford University — Stanford University (Nathan Van Patten)
Thomas, Earl C.
Stockton—Burke, J. M.
Watsonville — Granite Rock Co. (R. E. Fowle)
Wilmington—Los Angeles Harbor Dept. (G. F. Nicholson)

Colorado

Boulder—Gilkey, Herbert J.
Raeder, Warren
Denver—Cox, O. H.
Gowdy, Roy C.
Haring, Elias E.
Kirchhof Constr. Co., F. J. (F. J. Kirchhof)
Meade, P. F.
Northwestern Terra Cotta Co., The. (Geo. W. Mueller)
Pierce Testing Laboratories, The. (George Pierce)
Ruettgers, Arthur
Savage, J. L.
Shankland, Ristine & Co. (R. G. Shankland)
Simpson, Jr., Co., Alex. (Alex. Simpson, Jr.)
Steele, Byram W.
Stiefel, Alfred C.
Weber, Walter R.
Williams, Jay T.
Fort Collins—Road Materials Testing Laboratory. (C. A. Carpenter)
Julesburg—Parker, Philip M.

Connecticut

Bridgeport — Bridgeport Stone Co., The. (Frank E. Clarke)
Fletcher - Thompson, Inc. (Edward A. Lambert)
Clinton — Chittenden, Howard L.
Darien—Woodruff, G. B.
Hamden — Dextone Co., The (Louis A. Falco)
West Hartford—Crosby, Henry L.
Poriss Co., The S. C. (S. C. Poriss)
Hartford—Balf Company, The Edward
Ennis, Wm. J.
Hartford, City of (Philip A. Mason, Bldg. Supervisor)
Linnell, Frank A.
Mylchreest, G. L.
Windsor Cement Co., Inc.
New Haven—Blakeslee & Sons, Inc., C. W. (W. T. Gilbert)
Connecticut Quarries Co., Inc., The (A. L. Worthen)
Crane, Theodore
Gillon, Frank
Roberts, H. W.
Portland — Conn. State Highway Dept. (F. G. Flood)
Stamford — American Sewage Disposal Co., Inc. (F. M. Brown, Pres.)
Stratford—Lake, Simon
Westbrook—Morrill, Geo. P.

Delaware

Dover — Delaware State Highway Dept. (W. W. Mack, Ch. Engr.)
Middletown—Reaves, G. M.
Wilmington—Art Stone & Tile Co. (Arthur Pavoni)

District of Columbia

Washington — Allen, T. Warren
Bates, P. H.
Bogue, Robert H.
Bradbury, R. D.
Burggraf, Fred
Clemmer, H. F.
Crum, R. W.
Davis, Watson
Denton, W. Edward
Drew Co., Inc., Fred. (Fred Drew)
Dwyer, John R.
Earley, John J.
Edwards, Llewellyn N.
Fishburn, Cyrus C.
Ginder, J. W.
Ingberg, S. H.
Jackson, F. H.
Lapham, John R.
McDaniel, Allen B.
Marsh, Earl G.
Marshall, Thos. W.
Morgan, Nathan W.
National Crushed Stone Association. (A. T. Goldbeck)
National Lime Association. (W. V. Brumbaugh)
National Paving Brick Mfgs. Association (F. G. Schlesinger)
Oehmann, John W.
Parsons, Douglas E.
Proudley, C. E.
Rapp, Paul
Raywid, Leo.
Rich, Melvin S.
Ross, Culbertson W.
Rossman, Joseph
Ruebsam, Ernest C.
Saum, Irving R.
Schuman, Louis
Tompkins, Charles H.
Toner, A. C.
Trainor, Lee S.
Tucker, Jr., John.
Upham, C. M.
Walker, Stanton.
Wells, Hewitt
Yingling, Clinton K.

Florida

Daytona Beach — Florida Concrete Products Assn. (Walter Snead, Secy.)
Gainesville — Driggers, Clyde
Florida State Road Dept. (H. C. Weathers)
University of Florida.
Melbourne — VorKeller, Albert
Miami—Hannock, Charles F.
West Palm Beach — Chace, Clyde B.
Panama City—Southern Kraft Corp. (Erling Riis)
Tampa—Florida Portland Cement Co. (Cyrus N. Wells)

Georgia

Atlanta — American Memorial Co. (T. J. Meldrum)
Harris, Robert Olin
Lose, Robt. G.
McCrary Engineering Corp., J. B. (E. C. Catts, Purch. Agt.)
Marshall, Jr., Jos. M.
Oliver, Herbert D.
Spiker & Co., W. C. (William C. Spiker)
Willingham - Little Stone Co. (H. S. Willingham, Pres.)
Willson, S. H.
East Point—Slack, Searcy B.
Macon—Elkan, Stanley A.
Savannah — Cut Art Stone Co. (M. E. Kleinsteuber)
Washington—Shelverton, W. L.

Idaho

Boise — Department of Public Works. (J. D. Wood)
Wiley, A. J.
Pocatalleo—Althof, L. W.
Priest River—Robertson, R. R.

Illinois

Alton—Rodgers, Eben
Arlington Heights—Arlington Concrete Products Co. (Paul C. Taege)
Champaign—Johnson Co., C. S. (Chas. S. Johnson)
Nelsen Concrete Culvert Co., Inc. (E. P. Shapland)
Oliver, William A.
Chicago—Affleck, B. F.
Aldrich Construction Co. (J. W. Trickel, Pres.)
Allan, W. D. M.
Allen, O. T.
American Concrete Marbelite Co. (Paul K. Fleming)
American Concrete Pipe Association. (M. W. Loving)
American System of Reinforcing. (J. T. Hanley)
Anderson, Arvid A.
Architectural Stone Co. (Nelson A. Friis)
Associated Metal Lath Mfrs. (Wharton Clay)
Babcock, E. P.
Bartlett, G. S.
Battey & Kipp, Inc. (P. L. Battey)
Baylis, John R.
Bedford Construction Co. (N. H. McKenzie)
Bennett, J. Gardner
Benson Concrete Co. (C. H. Johnson)
Brown, J. F.
Brundage, Avery
Bullen, Carroll A.
Burrell Engineering & Construction Co. (Joseph Wilson, Secy.)
*Calumet Steel Co. (F. G. Carrol)
Capouch, M. E.
Cement Gun Construction Co. (John V. Schaefer)
Chicago Art Marble Co. (M. S. Marcus. Pres.)
Colburn, D. S.
Colorway, Inc. (Marshall R. Rust)
Concrete Publishing Co. (Norman M. Stineman)
Concrete Reinforcing Steel Institute. (R. W. Johnson)
Condron & Post. (C. L. Post)
Consolidated Cement Corp. (A. W. King)
Cummings, A. E.
Curtis, Benjamin J.
Cutler, Stanley G.
Davis, E. E.
DeLeuw & Co., Charles E.
Dillingham, George M.
Doucha, J. C.
Electric Tamper & Equip Co. (M. I. McCarty)
Emerson, H. B.
Engel, W. L.
Epstein, A.
Erickson, Ralph E.
Ericsson Co., Henry
Farmer, Homer G.
Federal American Cement Tile Co. (A. B. Shenk)
Floto, Julius
Foster, Winslow H.
Fridstein, Meyer
Gardner, Franc E.
Gonnerman, H. F.
Hart, W. E.
Harza L. F.
Hoeffer & Co., (Alexander C. Warren)
Holabird & Root. (E. A. Renwick)
Humboldt Mfg. Co. (Louis H. Martens, Pres.)
Hyde, George A.
Illinois Steel Co. (E. B. Harkness)
Ingemanson, Thure W.
Inland Steel Co. (A. C. Roeth)
Johnson, A. W.
Johnson, Otis Floyd
Kalinka, J. E.
Kalman Floor Co., The. (C. E. Cooke)
*Kalman Steel Co.
Keatinge, Paul F.
Kinney, William M.
Krause, L. B.
Langdon, E. W.
Langeler, M. Bert
Larson, D. E.
Leffler, Ralph R.
Lieberman & Hein. (E. Lieberman)
Lindau, A. E.
Lindsay, G. L.
Logeman, R. T.
Lord, Arthur R.
Lowell, J. W.
Lubin, Frank
Lynch, W. J.
McCaully, W. H.
McKay, Richard T.
McKeague, E. D.
McKinstry, Ross W.
McMillan, Franklin R.
Mack, Thomas
*Marquette Cement Manufacturing Co. (R. R. Coghlan, Chem. Engr.)
Martin, Edgar.
Masonite Corporation (E. B. Bushnell)
*Massey Concrete Products Corp. (E. C. Alexander)
Moore, O. L.
Moulton, A. G.
Oesterblom, I.
Pearse, Langdon
Pease, B. S.
Perfected Burial Vault & Cement Products Co. (H. A. Dahlquist, V. P.)
Perry, J. P. H.
Pettersen, Thomas
Phillips, R. S.
Powers, Treval C.
Rader, B. H.
Rail Steel Bar Association. (H. P. Bigler)
Randall, Frank A.
Ritter, Louis E.
Roberts & Schaefer Co. (E. E. Barrett, Pres.)
Rock Products. (Nathan C. Rockwood, Editor)
Rush, D. B.
Sargent & Lundy, Inc. (J. C. Sanderson)
Sauermann, Otto
Scheidenhelm Co., Edward L. (Edward L. Scheidenhelm)
Schuettge, Ralph T.
Schwantes, E. J.
Seidensticker, F. W.
Severin Co., N. P.
Shapiro, Benj. B.
Shideler, J. Raymond
Sisalkraft Co., The. (E. T. Anderson, Pres.)
Smith & Brown. (Albert Smith)
Spooner, Chas. W.
Stern, I. F.
Stone Brick & Block Works, Inc. (Paul E. Scott, Pres.)
Strauss, Joseph B.
Suhr, Berryman Peterson & Suhr. (Ivan C. Peterson)
*Universal Atlas Cement Co. (B. F. Affleck, Pres.)
*Universal Atlas Cement Co.
Van Houten, Chas.
Van Trump, Isaac
Voshell, James T.
Walker, C. G.
Walker, Frank R.
Wallace, Robert W.
Warren, George E.
Weber, Lester N.
Whitacre Engineering Co. (Arthur Hagener)
White, William E.
Wilson, Raymond
Wilson & Co., R. F. (R. F. Wilson)
Winokur, M. C.
Witt, J. C.
Wright, Harold B.
Chillicothe — Weidman, H. P.
Danville—Dierstein, A. L.
Western Brick Co. (E. T. Strawbridge)
Decatur—Traver Supply Co., W. G. (W. G. Traver)
Des Plaines—Des Plaines Concrete Products Co. (Chas. Gatzke)
Downers Grove—William M. Labastille
Pyramid Company (W. H. Frazier)
East St. Louis—Gain, Elmer W.
Mepham & Co., Geo. S. (L. K. Ayers, V. P.)
Elmhurst — Elmhurst-Chicago Stone Co. (Martin Hammerschmidt)
Evanston—Coy, Frank A.
City of Evanston. (E. M. Goodman)
Maney, G. A.
Nielsen, Frederick E.
Shields, H. C.
Glen Ellyn—Clarahan, Jr., Charles H.
Granite City — Hilker Supply Co. (E. W. Hilker)
Hinsdale—Brock, Arthur S.
Joliet — Ideal Concrete Co. (John G. Segenberger)

Ideal Concrete Co. (John G. Segenberger)
LaGrange—Ramm Co., E. L. (E. L. Ramm)
La Salle—Marquette Cement Mfg. Co. (C. M. Butler, Chief Chemist)
Mattoon—Goetz, John A.
Maywood—Chicago Architectural Stone Co. (M. A. Williams)
Moline — Axel-Carlson Co. (Curt Lundeen)
Oak Park—Concrete Bldg. Units Co. (P. F. Huxhold, Secy.)
Ottawa — Ottawa Silica Co. (P. S. McDougall, General Manager)
Peoria—Hill, W. N.
Hoerr, Philipp J.
Waterman, L. R.
Quincy—Buerkin & Buerkin. (Julius A. Buerkin)
Springfield — Illinois Division of Highways, Bureau of Materials.
Russell, Howard W.
Smith Chemical Works, Inc., Geo. B. (R. R. McCoy)
Stockton—Klassy. K. H.
Urbana—Bauer, E. E.
Brown, Rex L.
Crandell, John S.
Cross, Prof. Hardy
Foster, W. A.
Huntington, W. C.
Ketchum, M. S.
Lansford, Wallace M.
Morgan, N. D.
Murphy, Glenn
Newcomb, Rexford
Putnam, Wm.
Richart, F. E.
Roy, N. H.
Schwalbe, William
Talbot, Prof. Arthur N.
Tomita, M.
Westergaard, Harold M.
Winnetka — Windes & Marsh. (Frank A. Windes)
Winnetka, Village of (Robt. L. Anderson)
Wood River — Kienstra Bros. Fuel & Supply Co. (Frank T. Kienstra)

Indiana

Bedford—Huber, Lee
East Chicago — Youngstown Sheet & Tube Co., The. (C. M. Bradley)
Hammond—Federal Cement Tile Co. (J. George Geyer, Gen. Supt.)
Indianapolis — *Baker & Co., Hugh J. (Hugh J. Baker)
Geupel, Carl M.
Hall Construction Co.
Harrison, Merritt
Independent Concrete Pipe Co. (R. D. Robertson)
*Indiana Portland Cement Co. (Geo. E. Pierson, Mgr.)
*Insley Mfg. Co. (Alvin C. Rasmussen)
Kellam, Fred
Miesenhelder, P. D.
Miller, L. C.
Ratcliff, T. R.
Stackhouse, A. V.
W. Lafayette—Crepps, R. B.
Springer, G. P.
Lafayette—Freel, W. I.
Hatt, William K.
Hollister, S. C.
Kemmer, A. E.
Peru—Automatic Sealing Vault Co., The (C. C. Millhouse)
Richmond — Mueller, J. W.
Wabash—Philpott, James H.

Iowa

Ames—Morris, Mark
Stoddard, A. E.
Bettendorf —Bettendorf Co., The. (R. M. Bowling)
Buffalo—Breitengross, R. A.
Cedar Rapids — Cinder Block & Material Co. (H. L. Spaight)
Green, Howard R.
Davenport — Crabbs, Austin
Dewey Portland Cement Co. (K. P. Ferrell)
Priester Construction Co. (O. F. Priester)
Des Moines — American Vibrolithic Corp. (H. L. Tillson, Chief Engr.)
Iowa Concrete Crib & Silo Co. (H. E. Kilmer, Gen. Mgr.)
Mandia, Jas. V.
Patzig, Monroe L.
Steiner, W. H.
Weitz, Fred W.
Iowa City — Hands, Stanley M.
Mavis, F. Theodore
Iowa Falls—Welden, E.
Mason City — Northwestern States Portland Cement Co. (G. C. Blackmore)
Moville—Everart, C. C.
Oskaloosa—Carlon Construction Co. (Harry F. Carlon)
Sioux City—Everist, Inc., L. G. (H. C. Boswell)
Johnson, T. H.
Klinger, W. A.
*McCracken Machinery Co. (R. M. La Due)
Waterloo—Waterloo Concrete Corp. (C. L. Douthett, Pres.)
Zeidler Concrete Products Mach. Co. (A. W. Schultz)

Kansas

Chanute — Gardner, Guy O.
Clay Center—Wheelock, D. L.
Hutchinson — Grothe, Wm. F.
Hertz, H. P.
Phillips, Leroy
Kansas City—Wilson, L. Clyde
Manhattan — Koenitzer, L. H.
Scholer, Prof. Charles H.
Topeka—Haegert, Lee V.
Wichita—Cement Stone & Supply Co. (B. F. Krehbiel, Mgr.)
Waddington, C. V.

Kentucky

Frankfort — State Highway Dept. (J. S. Watkins)
Lexington—Congleton Co. W. T. (W. T. Congleton)
Des Cognets & Co., Louis (E. R. Ackerman, Secy.-Treas.)
Terrell, D. V.
Louisville — American Builders Supply Co. (Jas. F. McCracken)
*Kosmos Portland Cement Co. (A. W. Horner)
*Louisville Cement Co. (W. S. Speed, Pres.)
Speed Scientific School. (W. B. Wendt)
St. Matthews—Russell & Co., J. F.

Louisiana

Baton Rouge — Cramer, M. J.
Kivett, Edward H.
Crowley—Bernard, Merrill
Monroe—Barr, Charles S.
New Orleans—DePass, M. B.
Derickson, Donald
Glover Co., Geo. J.
*Lone Star Portland Cement Co. (Scott Thompson)
McNiven, J. A.
Montz, A. S.
Olsen, Ole K.
Porter, John L.
Portland Cement Assoc. (W. G. Hudson)
Sawyer, H. A.
Shilstone, Herbert M.
Standard Concrete Pipe & Curbing Co.
Watkins, M. M.
Shreveport—Freeman, E. M.

Maine

Augusta — Mason, Frank H.
Biddeford—Howard, S. B.
Brunswick—Maine Concrete Co. (W. A. Jack)
Orono — Technology, Experiment Station
Portland—Goddard. Calvin S,

Maryland

Baltimore—Baltimore Bureau of Standards (Conrad Zieget, Jr.)
Bryant, Charles B.
Cinder Block Corporation (G. W. Creighton, Gen. Mgr.)
Cummins, Charles A.
Doeleman, Herman F.
Fahm, Jr., Frank
Greiner, J. E.
Kirwan, Kenneth K.
Lane, H. A.
Lang, Jr., Philip George
Meyer, A. A.
Moore, Thos. V.
Pennsylvania Water & Power Co. (N. B. Higgins, Asst. Ch. Eng.)
Saxe, Van Rensselaer P.
Wich, John F.
Chevy Chase—McBurney, J. W.
College Park—Maryland, University of (A. N. Johnson, Dean)
Cumberland—Iron City Sand and Gravel Co. (E. J. Kean)
Hagerstown — Ferguson & Co., J. B. (J. B. Ferguson)
Muirkirk—Waldo, Inc., E. M. & F. (Edward M. Waldo, Pres.)

Massachusetts

Belmont—Yeats, Alex J.
Boston — *Aberthaw Co. (L. C. Wason)
Accuvad, J. G.
Associated Factory Mutual Fire Ins. Co. (C. K. Stiff)
Barrows, Frank G.
Boston Building Dept. (Edw. W. Roemer, Commissioner)
Boston Transit Mixers, Inc. (John T. McMorrow)
Brazer, George H.
Brown, Burtis
Burke, John A.
Burns, Inc., D. F. & W. G. (Walter G. Burns)
Cinder Concrete Units Corp. (Stephen Kearney)
Colby, Edwin W.
Cutler, M. H.
Densmore, LeClear & Robbins (Henry C. Robins)
Deslauriers Column Mould Co., Inc. (Henry A. Dahlen)
Dockstader, E. A.
Dutton, Earl S.
Emerson-Norris Co. (Frederick A. Norris)
Fay, Frederick H.
Gray, Howard Allison
Grid Flat Slap Corp. (Edwin F. Allbright)
Harty, John J.
Hersum, LeRoy M.
Jackson & Moreland (E. H. Cameron)
Kerr, Linton
Linenthal, Mark
Lockwood Greene Engineers, Inc., (H. E. Cousins)
MacMillan, A. B.
MacNaughton Co., Inc., P. J. (P. J. MacNaughton)
Macomber, C. Clark
Main, Charles T.
Matthews, L. H.
Metcalf & Eddy (Frank A. Marston)
Moore, Lewis E.
Monks & Johnson (B. A. Rich)
Nichols, Charles Eliot
Nichols, John R.
Northeastern University (Henry B. Alvord)
Norton, Paul W.
Perkins, G. Howard
Reed Co., William T.
Reidy, Maurice A.
Rowe, Hartley
Sherman, Herbert L.
Stone & Webster (C. E. Nichols)
Thompson - Lichtner Co., Inc. (Miles N. Clair)
Thompson - Lichtner Co., Inc. (Sanford E. Thompson)
Towles, Thomas Thomson
Turner, J. M.
Underhill, P. H.
Worcester, J. R.
Brighton—Whelan, Frank H.
Brookline—Bryant, Henry F.
Cambridge — Adams, Ralph G.
*Boston Sand & Gravel Co. (Paul P. Bird)
California Stucco Products of N. E. (Napoleon M. Bernier)
Gow, Charles R.
Haertlein, Albert
Johnson, Lewis J.
Maeser, Mieth
Mitsch, John D.
Peabody, Jr., Dean
Scully Co., The (Geo. T. Rooney)
Seron, Levon
Swain, George F.
Tucker, Ross F.
Wilson, Francis W.
Concord — Brown, H. Whittemore
Dorchester—Dones, Samuel G.
Franz, Herbert J.
Fall River—Beattie, Roy H.
Beattie & Cornell
Jamaica Plain—Campion, William L.
Lawrence—Delaney, Wm. J.
Lenoxdale — Berkshire Gravel Co. (A. I. Newton)
Malden—Becker, Frank V.
West Medford — Allen, Cleveland
Allen, John E.
Medford—Freedman, J.
Mozzicato, James S.
Melrose—Hoyt, Glenn T.
Winchester, Frank W.
Middleborough—Trufant, Russel Alden
Millers Falls—Art Stone Co., The (I. L. Bartlett)
Natick—Carter, Wilfred E.
Newton Center—Mariner, W. Seward
Newton—Miner, Reginald B.
Sampson, George A.
Reading—Nelson, Dewey
Somerville—Hurley, John J.
Springfield—Annable, B. A.
Baker, R. K.
Clough, G. C.
Dowd, Daniel M.
Dube, Charles
Ley & Co., Inc., Fred T. (T. A. Pearson)
Roy, Joseph E.
Valentine Lumber & Supply Co. (Frank J. Murphy)
State Farm — Maynard, Arthur J.
Swampscott — Erickson, Jr., Arioch Wentworth
Waban—Mohr, H. A.
Watertown — Gallagher, John P.
Wellesley Farms—Hayes, Walter M.
Voss, Walter C.
No. Wilbraham—Birnie Sand & Gravel Co. (J. E. Bowker)
Worcester — Fiske-Carter Construction Co. (Burton C. Fiske)
Frost, Chamberlain & Edwards
Jacobson, G. W.

Michigan

Adrian — *Consolidated Concrete Machinery Co. (Eugene F. Olsen, Vice-Pres.)
Alpena—Besser Manufacturing Co. (J. H. Besser)
Ann Arbor—Ayres, Lewis, Norris & May
Emmons, W. J.
Eriksen, Edw. L.
Gram, Lewis M.
McConkey, George M.
Marshall, W. V.
Menefee, F. N.
Michigan, University of (R. L. Morrison)
Orbeck, Martin J.
Sherlock, R. H.
White, Alfred H.
Cement City—Taggart, A. D.
Coldwater — Wolverine Portland Cement Co.
Dearborn—Chamier, A. U.
Morrill, Arthur B.
Detroit — American Hume Pipe Co. (F. L. Klingensmith)
Ayres, F. C.
Bates, Harold W.
Blake, H. C.
Boomer, Roy E.
Burton, Frank
Ceglarek, Wallace
Charron, Louis
Concrete Block & Products Co. (Jos. A. Sattler)
Concrete Steel Fireproofing Co. (S. V. Taylor, Pres.)
Cooper, Gage W.
Detroit Bureau of Government Research (Harrington Place)

Detroit Cinder Block & Tile Co.
Detroit Department of Building & Safety Engr. (C. A. Daymude)
Detroit Edison Co.
Detroit Edison Co. (A. S. Douglass, Chief Engr.)
Detroit Public Library (Adam Strohm, Librn.)
Dept. of Street Railrays (P. A. Kerwin)
Detroit Testing Lab., The (W. R. DeGowin)
Detroit, University of, Library (David P. Gilmore)
Dever, Clare
Donaldson & Meier (H. W. Meier)
Elms, Stephen F.
Eyrick, Jr., George J.
Fenkell, Geo. H.
Gabriel Steel Co. (W. F. Zabriskie)
Hanneman Bros.
Hinchman, T. H.
Hoffman, L. R.
Hubbell-Hartgering & Roth (Clarence W. Hubbell)
*Huron Portland Cement Co. (J. W. Kennedy)
Kahn, Albert
Kearney, James C.
Koenig Coal & Supply Co. (A. J. O'Connor)
La Camera, Peter
Lake Ports Supply Co., The
Lenhardt, L. G.
Liskow, Fred L.
Long, J. F.
MacKenzie, W. S.
McMillan, E. C.
McRae Steel Co. (K. C. McRae)
Mason, Roscoe J.
Maul Co., The (Bruce F. Carty, Secy.)
Michigan Concrete Co. (E. H. Bingham)
Morse, Floyd C.
Outzen, Andrew N.
Perry, Ralph W.
Seeliger, Joachim Eberhart
Sexton, James E.
Stone, O. O.
Super Cement Co., The (W. J. D. Reed-Lewis)
Truscon Laboratories, The (R. A. Plumb)
Wasson, J. H.
Weaver, H. A.
Whipple, Harvey
Wilk, Benjamin
Williams, L. E.
Wolfe, W. S.

Escanaba—Sullivan, P. L.

East Lansing — Michigan State College (C. L. Allen)

Flint—Ortman, Frank A.
Robb, R. E.

Galien—Galien Concrete Tile Co. (C. A. Roberts, Secy.-Treas.)

Grand Rapids—Hamilton & Weeber (E. R. Weeber)

Lamar Pipe & Tile Co. (C. E. Edwards, Gen. Mgr.)

Jackson—Donovan, John B.
Everett, Roy E.
Stevens & Wood (Edw. M. Burd)
Willbee Concrete Products Co. (Charles E. Willbee)

Kalamazoo — Billingham & Cobb (L. A. Cobb)
Brassert, Walter
Lilly, J. A.

Lansing — Reniger Construction Co. (M. H. Reniger)
Van Eenam, Neil

Midland—Dow Chemical Co. (L. C. Stewart)

Mt. Clemens — Lehner, Walter J.

Muskegon—Lewis, H. J.

Newaygo — *Newaygo Portland Cement Co.

New Hudson—Standard Gravel Co. (O. E. Gooding)

Union City — Peerless Portland Cement Co. (William M. Hatch)

Minnesota

Duluth—Dickerson, Oliver H.
Josephs, Arthur C.
Kelly, E. W.
Pharis, L. M.
Vogt, R. C.
Polaris Concrete Products Co. (Gordon H. Butler)
Whitney Materials Co. (G. A. Whitney)

Elk River—Elk River Concrete Products Co. (D. W. Longfellow)

Minneapolis — Altman, Frank S.
Alrick, B. G.
Bergford, L. M.
Brockway, R. R.
Clark, Kenneth M.
Clousing, Louis
Fegles Construction Co., Ltd. (D. B. Fegles, Pres.)
Forrest, V. E.
Hughes, C. A.
Hustad Co., The (A. P. Hustad, Pres.)
Johnson, Algot F.
Kelley, J. W.
Lagaard, M. B.
Macgowan, Ernest S.
Minneapolis Street Ry. Co. (O. F. Moore)
Northern States Power Co. (G. E. Loughland)
Paul, Frederick T.
Sandstone Quarries Co., The (C. D. Lynds)
Straub, Dr. Lorenz G.
Thomson, Gordon
Turner, C. A. P.
Wheeler, Walter H.
White, C. J.
Young, Charles H.

St. Paul—Arnold Construction Co. (H. W. Small)
Capital Avenue Cement Works (A. O. Hovde)
Durr, C. Warren
Guaranteed Concrete Co. (A. R. Shiely, V. P.)
Hall, Quincy A.
King, W. E.
Loeffler, H. S.
Lovering-Longbotham Co. (Harry D. Lovering)
Minnesota Highway Dept. (F. C. Lang, Engr. of Tests & Insp.)
Minnesota Mining & Mfg. Co. (L. A. Hatch)
Schuett Meier Co. (A. Hs Schuett)
St. Paul Cement Work. (H. C. Berchem)

Mississippi

Meridian—P'Pool & Son, A.

Vicksburg — Birchett, Raymond

Missouri

Brentwood — St. Louis Concrete Products Mfg. Co. (Frank J. Grutsch)

Carthage—Wetzel, E. H.

Charleston—Quick, Jerry L.

Dalton—Laker Concrete Works (H. J. Laker)

Jefferson City—Missouri State Highway Dept. (F. V. Reagel, Engr.)
Remley, Norman W.

Kansas City—Anderson, W. R.
Black & Veatch (N. T. Veatch, Jr.)
Burns & McDonnell Engineering Co. (C. S. Timanus)
Cross, Roy C.
Dewey Portland Cement Co. (F. E. Tyler)
Erickson, Iver
Everham, A. C.
Haydite Co., The (Dan F. Servey)
Heidenreich, E. Lee
Jones-Hettelsater Constr. Co.
Horner & Wyatt (Roy M. Wyatt)
Hussey, Jack W.
*Kansas Portland Cement Co., The (J. A. Lehaney)
Logan, Edgar H.
Lundteigen, A.
Lyons, R. P.
McIntyre, Geo. E.
Nelson, G. V.
Nicholson, Geo. E.
Prince, John
Schramm, A. F.
Swanson, C. E.

St. Louis—Barnsdall Tripoli Co. (W. C. Bruce)
Becker, W. C. E.
Berg Vault Co. (Christy L. Berg)
Birkland, George
Colloy Production Co. (C. P. Derleth
Concrete Marble Co. (G. C. Turner)
Dailey Contracting Co., H. A.
Freuenfelder, Herman
Frech, H. E.
Friberg, Bengt.

General Material Co. (H. F. Thomson)
Hedderich, H. F.
Horner, Wesley W.
James, William
Knight, W. J.
Koerner, Carl A.
*Laclede Steel Co. (W. W. Scott)
McMahon, E. J.
Made-Rite Products Co. (Robert Fullerton, V. P).
Many, Ben J.
*Missouri Portland Cement Co. (H. C. Block, Pres.)
Parcel, John I.
Pettus, L. A.
St. LouisMaterial & Supply Co. (Otto S. Conrades)
Saeger, Geoff A.
Sweetser, Ernest O.
Tripp, J. G.
Verschleiser, J. H.
Wheeler, W. H.
North Kansas City—Allen, H. S.
Rolla—Butler, Joe B.
St. Joseph—Leslie Engrg. Co. (J. R. Leslie)
St. Joseph Cinder Block Co. (Robert Brown)
Zeidler, John L.
Springfield — Gray, William J.
Webster Groves — St. Louis Duntile Co. (Jos. Amend, Secy.)
Southwestern Engrg. Co. (L. D. Rosenbauer)

Nebraska

Columbus — Gottschalk, L. F.
Lincoln—Abel Construction Co.
Duff, C. M.
Grone, Edwin Arthur
Sampson, B.
Louisville—Frolich, A. K.
Omaha—Curtis, L. C.
Meyer, C. Louis
Moran Construction Co., The (Frank Moran, Pres.)
Rockwell, J. A.
Swanson, A. G.
Thee, T. C.
Union Pacific System (H. C. Mann)
Wemmer, H. P.

Nevada

Las Vegas—Patch, Orin G.
Wood, Douglas

New Hampshire

Bristol—Resseguie, H. D.
Concord — Purrington, Wallace F.
Lebanon—Downs, Allan B.
Seabrook—Schroedel, F. H.
Manchester — Shattuck, Inc., L. H. (George G. Shedd)

New Jersey

Ampere—Lock Joint Pipe Co. (J. E. Longley)
Lock Joint Pipe Co. (F. F. Longley)
*Lock Joint Pipe Co. (A. M. Hirsh, Pres.)
Arlington—Brandes, Raymond L.
Atlantic City—Ferry Co. Inc., James (James V. Ferry)
Markland, M. B.
Bellville—Brooks, Robert M.
Bloomfield—Teaze, Moses Hay
Bound Brook — Branda, Christopher
Camden—Concrete Specialties Co. (L. A. Goodwin, Secy.-Treas.)
Dunellen — *Ransome Concrete Machinery Co. (A. P. Robinson)
East Orange—Albert, Odd
Atwater, Ralph W.
Christie, H. A.
Deignan, John E.
Matthews, Howard B.
Pierson Co., J. W. (James T. Pierson, Vice-Pres.)
Ulrich, Thomas J.
Elizabeth — Chapman, John J.
Standard Oil Development Co. (Rayway) (Charles E. Haupt)
Fort Lee—Bergholm, A. O.
Haddonfield — Hewes, George C.
Irvington — Core Joint Concrete Pipe Co., Inc., (G. M. Kerr)
Lindsley Co., C. E. (C. E. Lindsley)
Jamesburg—Davison, R. Glenn
Jersey City—Gilligan, William H.
Hud-Cin Building Products Inc. (W. H. Blackwood)
Mitchell, James
Munsell, A. W.
Radigan, Frank J.
Sureseal Manufacturing Co. (Walter J. Gorman, Pres.)
Walter, L. W.
Wasser, T. J.
Leonia — Morrill, Albert H.
Linden—Porter, J. Miller
Manasquan—Vogel, John Leonard
Milville — Haddow, Jr., Hugh
Moorestown—Cone, G. R.
Morristown — McCune, Stephen
Newark — Anti-Hydro Waterproofing Co. (M. W. Meyer)
Bingham, George C.
Bound Brook Crushed Stone Co. (L. Upton)
Colwell, Curtis C.
Drill, Max
Farrell, J. I.
Igoe Brothers (Ralph F. Healy)
Kindle, W. H.
Mulroy-Cooke Company, Inc. (E. J. Mulroy, Pres.)
Newark Concrete Pipe Co. (Francis H. Sherrerd, V. P.)
New Jersey Dist. Water Sp. Comm. (Arthur H. Pratt)
Nutting Co. of N. J., H.C. (Dewey Thompson)
Porete Mfg. Co.
Powers, Ellwood D.
New Brunswick—Marin, Joseph
New Village—Edison Cement Co. (George C. Wilsnack)
North Bergen — Hudson Block & Supply Co., Inc., (W. J. Dicker, Gen. Mgr.)
Old Bridge—Nowell, Jr., Joseph C.
West Orange—Devonald, Ira R.
Orange—Fossum, L. T.
Mead-Suydam Co. (F. J. Mead, Pres.)
Paterson — Anderson, Walter A.
Federici, Albert
Ferguson, A. Donald
Ferguson Co, Inc., John W. (John W. Ferguson)
Hughes, R. G.
Jones, William M.
Torrey, James E.
Plainfield—Benham, Sanford W.
Loizeaux Lumber Co., J. D. (George B. Coale)
Port Monmouth—Freibott, George B.
Princeton—Begs, George E.
Ramsey—Conklin, James Arthur
Ridgefield Park—Bergen Building Block Co. (Howard Brooke)
Ridgewood—Evans, Frank M.
River Edge—Pirkner, Herbert R.
Rutherford—Fink, John C.
Summit — Rhett, Albert H.
Teaneck—Munsell, J. R.
Trenton—Andrews, L. E.
Friebele, J. F.
Gage, Robert B.
Robbins, Harry D.
Scheirer, M. K.
Schlottenmeier, Joseph F.
Sherman, Ralph A.
Upper Montclair—Mead, C. A.

New Mexico

Albuquerque—Holm, W. M.

New York

Albany—Colmar, Daniel
Greenman, Russell S.
Kelley, Frederick W.
*Lone Star Cement Co. New York, Inc. (D. P. Cooper)

Myers, Jasper M.
Ready Mix & Supply Corp. (N. D. Crowley, V. P.)
Amsterdam — Turner & Sons, John P.
Bayside—Johnston, Robert S.
Bronx—Blancato, Virgilis
Caiola, Fred
Liebeskind, Morris Moe
Smyth, Raphael J.
Usilton, L. H.
Waterside Concrete Works (Douglas S. Thropp, Gen. Mgr.)
Wood, James
Brooklyn — Abberley. Elbert K.
American Vault Co. (F. H. VanNess)
Bekay, A. V.
Caye Construction Co., Inc. (Webster J. Caye)
Central Concrete Mixing Corp. (A. Johnson)
Cranford, Inc., Frederick L. (F. L. Cranford)
Gallagher, A. C.
Hargen, Stanley
Hoyt, C. R.
Krier, George H.
Lindon, James J.
Moore, Roy Saxton
Piloff, Albert K.
Praeger, Emil
Roux, Maurice G.
Ryan Ready Mixed Concrete Corp. (Joseph J. Ryan)
Bronxville — Westchester County Park Commission (L. G. Holleran)
Buffalo — Bergner, Edward F.
Black Co., John H.
Buffalo Slag Co. (Carlton S. Wickers, Mgr.)
Buffalo Wash Tray Works, (H. A. Blanchard)
Burford, John Nicholas
Cook, F. W.
Cowper Co., John W. (John W. Cowper)
Danaher, W. E.
Degling, A. O.
Diehl, Inc., George C. (Ray P. Diehl)
Egelhoff, R. F.
Federal Concrete Co. (W. E. Jones, Secy.)
Fruchtbaum, J.
Great Lakes Concrete Pipe Co., Inc. (J. G. Miller, Treas.)
Locke, Clyde E.
Monarch Engrg. Co. (H. R. Wait, Pres.)
Muntz, E. P.
Neff, Stewart S.
Stelley, Harry A.
Thompson, Warren H.
*Turner Construction Co.
Ward, Harry A.
Wolf, Robert D.
Carthage — Brownell, Parker J.
Catskill—*North American Cement Corp. (H. F. Kichline, Chief Chemist)
North American Cement Corp. (G. A. White)
Clinton—Clinton Metallic Paint Co. (John Mott, Vice-Pres.)
Cornwall-on-Hudson — Mosher, Clarence H.
Croton - on - Hudson — Schulze, John C.
Floral Park—Pardee, Clarence G.
Glens Falls—*Glens Falls Portland Cement Co. (G. F. Bayle)
*Glens Falls Portland Cement Co. (Geo. F. Bayle, Jr.)
Gloversville — Art Stone Co. (A. C. Suits)
Harmon—Wolpert, Otto
Harrison — Thompson, John H.
Hudson—Weiler, Charles B.
Ithaca—Kuan, F. C.
O'Rourke, Chas. E.
Scofield, H. H.
Urquhart, L. C.
Vanderlip, A. N.
Ward, A. A.
Jackson Heights, L. I.—Halloran, Lt. P. J.
Winiger, Edward
Jamestown — Jamestown Block & Tile Co., Inc., (D. A. McClure, Treas.)
Lackawanna—Buffalo Art Stone Corp. (E. H. DeVoe)
Buffalo Litholite Company (George E. Hipp)
LeRoy — Rib-Stone Concrete Corp. (George E. Priest)
Long Island City—Horn, A. E.
Vago, Oscar J.
Mastic, L. I.—Ferrer, Russell R,
Mt. Vernon — Macneal, LeRoy C.
Newburgh — Heidenreich, Jr., E. Lee
New City—Eldridge, H. W.
New Rochelle— Meltzer, Joseph
Noyes, Haydon T.
Steljes, Martin
New York—Abrams, Prof. Duff A.
Ackerman, Frederick L.
Ambursen Construction Co. Inc. (L. A. Robb)
American Can Co. (C. E. Preis)
American Sika Corp. (Herbert Stoneham)
Anderson, Emanuel
Artstone Products, Inc.
Balcom, H. G.
Barbato, Theodore
*Barney-Ahlers Construction Corp. (John G. Ahlers)
Barney, William Joshua
Barry, L. C.
Barzaghi, Arthur J.
Bell Telephone Laboratories (J. M. Hardesty)
Benedict, James G.
Berg, U. T.
Bertin, René L.
Billner, K. P.
Binney & Smith Co. (J. T. Kealy)
Bird, Millard F.
Bissell, Clinton T.
Boyer, E. D.
Burke, Charles H.
Burrell, H. P.
Chapman, Cloyd M.
Chubb, Joseph
Christensen, Einar
Ciampa, Felix A.
Clos, Charles
Cobb, W. G.
Cohen, A. B.
Columbia University (Albin H. Beyer)
Conahey, George
*Concrete Steel Co. (James F. Curley)
*Concrete Steel Co. (John F. Havemeyer)
Concrete Steel Engineering Co. (Wm. Mueser)
Cooper & Co., Inc., Hugh L. (Hugh L. Cooper)
Cooper, Nelson
Cory, Russell G.
Coyle, David C.
Denton & Co. (P. E. Eisenmenger)
Di Stacio, Joseph
Dixon, D. H.
Dobbs, A. Harry
Dorr Co., Inc., The (W. A. Neill)
Doyle, Frank P.
Durbin, H. R.
Eddystone Cement Co. (E. R. Wilner)
Ellis, Warren L.
Falconer, R. C.
Ferro Building Products Co., Inc. (A. Hamburger)
Fertell, Arthur
Finlay, L. G.
Fischer, L. J.
Floyd, George F.
Fogg, Ralph J.
Fougner, Hermann
Fouilhoux, J. Andre
Foundation Co., The (A. Amson)
Francisco, F. LeRoy
Frankland, F. H.
Fuller & McClintock (Geo. W. Fuller)
Gannett, The J. K.
Gautier, R. C.
Giles, Roy T.
Gilman, Charles
Ginsberg, Frank I.
Glassett, Alfred T.
*Goodwin-Gallagher Sand & Gravel Corp. (John J. Gallagher)
Greenfield, Inc., Arthur (Arthur Greenfield)
Guarantee Constr. Co. (Edward Burns)
Gulick - Henderson Co. (Frank L. Greenfield)
Hadden, Gavin
Hand, Geo. T.
Harris, F. R.
Hay, William Wren
Hayden, R.
Holdsworth Patents Inc. (Harry Holdsworth)
Holz, Herman A.
Holtz & Co. Inc., R. B. (R. B. Holtz)
Hooks, James H.
Hool, George A.
Hunt & Co., Robert W. (J. F. Davis)

Industrial Engineering Co. (D. Traver Miller)
Infante, Percival M.
Integral Waterproofing Co. (Frank J. Phelan)
International Cement Corp. (Howard Rhode)
*International Cement Corp.
*International Cement Corp.
Johnsen, E.
Johns-Manville Corp. (Geo. A. Smith)
Jones, Bevan
Kaufman, David M.
Kinneman, W. P.
Kraus Process Inc. (J. Tyrell Cheney, Pres.)
*Lawrence Portland Cement Co. (E. P. Haubert)
Lawson, David
Lewis Asphalt Engineering Corp. (R. W. Lewis)
Litter, F. J.
McFarland, William G.
McGraw, George B.
McGrew, Jr., E. J.
McNulty, Joseph A.
Manley, Henry
Math, Earle R.
Merriman, Thaddeus
Meyer, Morrison & Co. (B. A. Meyer)
Miner, Joshua L.
Minwax Co., Inc. (Allrich S. Harrison, Vice-Pres.)
Moran & Proctor (G. L. Freeman)
Mueser, William H.
Murray, Inc., Thomas E. (J. R. McColl)
Nailcrete Corp., The (F. B. DeGress)
*Nassau Sand & Gravel Co. (W. J. Timberman)
National Fireproofing Co. (P. Bevier)
Nevin, Thos. M.
Nikitin, P. E.
*North American Cement Corp. (Thos. G. Mooney)
Osborn Co., C. J. (W. F. Purdy)
Parker, Frank S.
Pennsylvania-Dixie Cement Corp. (Blaine S. Smith, Pres.)
Plastic Stone Products Corp. (H. A. R. Zehrlaut, Pres.)
*Raymond Concrete Pile Co. (H. P. Hamlin)
Reichard - Coulston, Inc. (W. A. Kennedy)
Republic Fireproofing Co. Inc. (R. McWilliams)
Reynolds, Frank L.
Rheinstein Constr. Co. Inc. (A. Rheinstein, Pres.)
Richard, N. A.
Richardson, James H.
Roach, M. J.
Rose, Joseph
Rusk, W. Harrell
Rylander, Paul N.
Sanborn, Jas. F.
Sanderson & Porter
Schuster, K. R.
Seabury, George T.
Searl, Thomas D.
Seney, Howard I.
Simpson, Geo.
Smidth & Co., F. L. (O. E. Mogensen, Secy.)
Snare Corp., Frederick (Randall Creamer)
Springer, E. J.
Starrett Bros. & Eken, Inc. (Russell H. Hunter)
Steinman, D. B.
Stephens, A. W.
Stephenson, L. E.
Stern, Eugene W.
Stevens & Wood, Inc. (F. E. Murphy)
Stewart & Co., Inc., James (H. W. Lohmann, Vice-Pres.)
Struckmann, H.
Stuart, Francis Lee
Sundstrom, C. A.
Thompson & Binger (W. D. Binger)
Thompson, James
*Thomson-Starrett Co.
*Toch Bros., Inc. (Maximilian Toch)
Toch Bros., Inc. (Maximilian Toch)
Tomes, P. Austen
Tozzer, A. C.
Turner, Jr., Henry C.
*Turner Construction Co. (E. J. Moore)
*Turner Construction Co. (H. C. Turner)
Underwriters Laboratories (A. R. Small)
*Universal Atlas Cement Co. (E. K. Borchard)
*Universal Atlas Cement Co. (C. R. Hulsant)
Upson, Maxwell M.
Van Buren, Maurice P.
Vandever, Jacob B.
Van Name, R. L.
Voorhees, Gmelin & Walker (Richard A. Backus)
Vulcanite Portland Cement Co. (Albert Meyer)
Warren, Francis B.
Webster, Daniel T.
Weir, C. Leslie
Wheadon, Roynton F.
Whitcraft, L. N.
*White Construction Co., Inc. (G. Edward Escher)
Wigton, C. B.
Wiles, J. R.
Woodard, Silas H.
Wortman, Dietrich
Ytterberg, C. F.
Zipprodt, Roy R.

Queens, L. I.—Furphy, LeRoy F.

Niagara Falls—Wright & Kremers, Inc. (Ernest Kremers)

Nunda—Foote Co., Inc., The (Charles A. Lynch)

Pelham Harbor—Wilcox, Fred C.

Pittsford—Klock, Morgan B.

Rochester — Alexander, Shumway & Utz Co., The (Chas. A. Alexander)
Calif. Stucco Products Co. (H. D. Kneeland)
Campbell, S. A.
Consolidated Materials Corp. (Henry F. Marsh)
Fairchild, LeRoy F.
Norris, J. F.
Rochester, City of, Director of Design and Construc- (Henry L. Howe)
Sanford, L. M.
Scherer, Francis R.
Whitmore, Rauber & Vicinus (L. S. Whitmore, Vice-Pres.)

Rockville Center — Spelman, John R.
Wilson, Francis F.

St. Albans—Mayr, J. T.

Saratoga Springs—Blanchard & Crandell (A. E. Blanchard)

Schenectady — Eighmie, Borden C.
Matlin, W. S.
Union College, C. E. Dept. (Prof. Henry A. Schauffler)

Syracuse—Broga, George F.
Eddy, W. Paul
Eells, W. C.
Paolini, Alfred J.
Solvay Process Co., The
Thomson, Duncan

Troy—Lawson, Thomas R.

Utica—Beebe, Inc., H. R. (H. R. Beebe)

Valley Stream — Smith, George J.

White Plains — Farrell, John J.
Hepburn, William
Solomon, Morton
Weed, Lloyd W.

Woodside, L. I.—Baranzelli Cast-Stone Inc. (G. Baranzelli, Pres.)

Yonkers—Hernandez, Inc. Clinton N. (Clinton N. Hernandez)

North Carolina

Chapel Hill—Hickerson, T. F.

Charlotte—Lee, W. S.
Ornamental Stone Co. (W. J. McCanless, Pres.
Sitton, G. L.

Durham — Duke University Library (Harold C. Bird)
Muirhead Construction Co. Wm. (Wm. Muirhead)

Greensboro—Webb, Stafford

Highland—Sewell, John S.

High Point—Carrick, T. Bright

Hot Springs—Rawls, E. M.

Thomasville—Gray Concrete Co. (F. B. Gray)

North Dakota

Bismarck — Ritterbush Bros. (Robert A. Ritterbush)

Fargo—Fargo Stone & Sand Co. (Joe Ames, Jr.)

Ohio

Akron—Akron, University of (E. F. Schaefer)
Bulger, John

Ashland—Ashland Vault Inc. (H. A. Ledyard, Pres.)

Blue Ash—French, R. M.
Bremen—Stuart, J. H.
Canton—Landor, Edward J.
Cincinnati — Avril Tru-Batch Concrete, Inc. (A. C. Avril, Pres.)
Backman, L. J.
Baldwin, F. G.
*Carey Co., Philip (C. V. R. Fullenwider)
Cincinnati Builders, The (Julius J. Warner)
Cinder Products Inc. (W. Keith Clark)
Dugan Concrete Co.
Evans, L. T.
Euphrat & Hanly (Hunter W. Hanly)
Ferro Concrete Construction Co. (W. P. Anderson)
Ferro Concrete Construction Co. (H. D. Loring)
Garties, George
Goldsmith Metal Lath Co., The (Louis I. Zagoren)
Gould, Harley J.
Hackett, Thos. P.
Hagy, Ernest A.
Hannaford, H. Eldridge
Harding, E. C.
Hodges Construction Co., The (J. E. Hodges)
Johnson, Wm. R.
Morrill, F. W.
Myron, J. A.
Nelson, Norman
Nutting Co., H. C. (C. O. Christy)
Panzer, R. R.
Penker Construction Co., The (Irwin A. Penker, Pres.)
Pollak Steel Co., The (Julian A. Pollack, Vice-Pres.)
*Roos Co., H. W. (H. W. Roos, Pres.)
Roos Co., The H. W. (H. W. Roos)
Roos - Meyer - Hecht Co., The (Geo. W. Meyer, Secy.)
Van Camp Stone Co. (J. H. Liggett)
Waite, H. M.
Ward, William B.
Wetstein, Mentor
Cleveland—Allemann, W. T.
Bolton Pratt Constr. Co. (K. H. Pratt)
Bourne, C. L.
Burger, Alfred A.
Case School of Applied Science (F. H. Neff)
Churchill, H. D.
Daniels, F. W.
Douglas, M. S.
Dykeman, Howard E.
Eberling, C. M.
Emerson Co., The Sam W. (R. E. Laubscher)
Feher, Francis
Forest City Testing Laboratory, The (C. H. Lovejoy)
Grasselli Chemical Co. Inc., The (R. F. Remler)
Hansen, Ralph
Herron Co., The James H. (James H. Herron)
Humphrey, D. S.
Jacoby, H. S.
Johnson, Axel H.
Lambie, J. Edward
Love, Harry J.
Lundoff-Bicknell Co. (C. W. Lundoff)
Master Builders Co., The (S. W. Flesheim)
*Medusa Portland Cement Co. (R. E. Withrow)
Metropolitan Concrete Co. (W. H. Crangle)
Minton Scobell Co. (J. H. Minton)
Morrow, David W.
Osborn Engineering Co., The (K. H. Osborn)
Pease, F. A.
Rackle & Sons Co., The Geo. (Geo. L. Rackle, V. P.)
Rackle & Sons Co., The George (E. E. Rackle, Pres.)
Rawson, R. A.
Rivet-Grip Steel Co., The (H. A. Stuart)
Rogan, W. B.
Scripture, Jr., Edward W.
Sowers, Geo. B.
Stoddard, Ralph P.
Summers, R. E. J.
Thompson, G. Saxton
Thompson, W. N.
Wertz Co., The (Louis S. Wertz, Pres.)
Watson & Associates, Wilbur (W. J. Watson)
Columbus—Anchor Concrete Machinery Co. (G. M. Friel, Mgr.)
Arrow Sand & Gravel Co., The (S. Stepanian, Vice Pres. & Gen. Mgr.)
Blanchard, F. E.
Brown, R. L.
Burgess, Philip
Collins, H. G.
Columbus Testing Laboratories Inc. (A. B. Braden, Pres.)
Concrete Engineering Service Co. (H. C. McCall, Ch. Engr.)
Cunard Lang Concrete Co. (L. D. Hagerty)
Elford, H.
Hindman, W. S.
Lakewood Engineering Co. (Lion Gardiner, Vice-Pres.)
Large, George E.
Morris, Clyde P.
Shank, J. R.
Dayton—Clement, R. B.
Condit, G. H.
Crume Brick Co., The (W. H. Crume)
Schad, Bernard T.
Smith, Oscar S.
East Liverpool—Frosch, A. E.
Evanston—Fisher-DeVore Construction Co. (Frank F. Fisher)
Greenville — American Aggregates Corp. (Guy C. Baker)
Hamilton — Hamilton Gravel Co. (W. P. Watson, Secy-Treas.)
Kingston — McBeth, R. W.
Lakewood — Deinboll, F. K.
Feldrappe, M. G.
Withrow, Roe E.
Lisbon—Thomas & Sons Co., The R. (H. P. Sleeman)
Newark—Kerr, George W.
Wyeth-Scott Co., The (W. D. Wyeth, Pres.)
Osborn—Jennings, Wm. A.
Painesville — Standard Portland Cement Co. (Erie J. Ochs, Supt.)
Portsmouth — Goodman, Hal W.
Silica—Sleight, T. R.
South Park — Hydraulic Press Brick Co.
Toledo—Bates, Frederic G.
Blanchard, Arthur H.
Champe, Geo.
Finishing Lime Assoc. of Ohio, The (L. E. Johnson)
Hausman, Steel Co., The
Kriege, Herbert F.
Kuhlman Builders Supply & Brick Co., The (C. E. Kuhlman)
McKee, S. C.
National Cement Block & Supply Co., The (C. B. Fellabaum)
Rhines, Geo. V.
Spieker Co., The Henry J. (W. E. Condit)
Toledo Concrete Pipe Co., (L. J. Loughlin)
Warren—Harm, George O.
Youngstown—Applegate, L. M.
Gorsuch, V. D.
Hubbard, Fred
Irwin, Orlando W.
Nixon, H. O.
Roscoe, Ralph E.
Snodgrass, R. D.
Standard Slag Co. (F. E. Miller)
*Truscon Steel Co. (Julius Kahn, Pres.)
Youngstown Burial Vault Co. (E. E. Kling)

Oklahoma

Ada—Bayless, O. A.
Duncan — Halliburton Oil Well Cementing Co. (Hayden Roberts, Chemist)
Holdenville—Votaw, Curtis H.
Oklahoma City—Brown & Myers
Clark, B. E.
Eckert, Ralph T.
Harter-Marblecrete Stone Co. (B. D. Harter)
Oklahoma Testing Laboratories (Wm. Furber Smith)
Verity, Fred L.
Stillwater—Lothers, John E.
Oklahoma A. & M. College, (Mrs. Elsie D. Hand, Librn.)
Saxton, Ren G.

Tulsa—Oklahoma Glazed Cement Pipe Co. (J. N. Chandler, Pres.)

Oregon

Albany—Harber, G. Peyton
Corvallis—Glenn, B.
Waterman, Ivan F.
Owyhee—Betts, Clifford A.
Portland—Alin, A. L.
Claussen & Claussen, Inc. (W. E. Claussen, Secy-Treas.)
Cooper, Miles K.
Hammond, Inc., Ross B. (Ross B. Hammond)
Henny, D. C.
Nichol, F. E.
Nims, Chas. B.
Standard Art Stone Co. (T. J. Schmidt)
Thomas Cast Stone Co., Ernest (Ernest Thomas, Pres.)
Salem—Paxson, C. S.

Pennsylvania

Aliquippa—Stetson, F. M.
Allentown — Ashton, Ernest
Brickett, Edward M.
Cement-Gun Co., Inc., (B. C. Callier)
Hollywood Building Block Co. (Paul R. Klotz)
*Lehigh Portland Cement Co.
Lehigh Portland Cement Co. (E. M. Young, Pres.)
*Lehigh Portland Cement Co. (E. M. Young, Pres.)
Lehigh Portland Cement Co.
McCready, E. F.
Meckley, E. W'
Oscar, L. C.
Pearson, J. C.
Watt, A. G.
Young, Roy N.
Ambler—Asbestos Shingle, Slate & Sheathing Co. (Richard V. Mattison)
Bethlehem — Kreidler, Carl L.
Lyse, Inge
Parkinson, G. W.
Slater, Willis A.
Sutherland, Hale
Bryn Mawr — Vauclain, Jacques L.
Butler—West Penn Cement Co. (O. J. Binford)
Carlisle—Horner, J. M.
Catasauqua — Allentown Portland Cement Co. (R. S. Weaver)
Fuller Co. (P. F. Stauffer, Sales Mgr.)
Cementon—Hoke, Arnold
Center Square—Young, Jr., Fred W.
Columbia—Rule, H. Paul
Easton—*Alpha Portland Cement Co. (Louis Anderson, Jr.)
*Alpha Portland Cement Co. (F. G. McKelvy)
Bragg, J. G.
Dewson, S. H.
Messinger Supply Co. (Dr. Wm. Mock, Secy.-Treas.)
Williams & Co., C. K. (E. G. Davies, Vice-Pres.)
Erie—Erie Patent Block Co.
Johnson, W. P.
Nickel Plate Sand & Gravel Co. (H. F. Rath, Sec.)
*Shenk Co., Henry (E. R. Shenk)
Wadsworth, John Frederick
Frankford—Button, William G.
Franklin—*Franklin Steel Works (E. E. Hughes)
Gettysburg—Clutz, Frank H.
Glenside — Albright & Mebus (Charles F. Mebus)
Friel, Francis S.
North Glenside—Doane, Louis H.
Eitzen, Henry R.
Harrisburg—Masters, F. M.
Pennsylvania State Highway Dept. (W. H. Connell)
Ulman, Malcolm H.
Kingston — Nepenna Building Materials Co. (F. L. Schott)
Lancaster — Krewatch, Wm.
Lancaster Concrete Tile Co. (Henry Boettcher, Pres.)
Malone, John A.
Wickersham, John H.
Lansdowne — Kirk, Joe Neil
Mahanoy—Jones, William A.
Marcus Hook — Delco Concrete Products Co. (G. L. Crosgrove, Mgr.)
Milmont Park—Denuel, J. M.
Mount Union—Andrews, E. T.
Moylan—Radbill, Ray
Nazareth—Champion, E. C.
*Hercules Cement Corp.
*Nazareth Portland Cement Co.
Robeson, Harold B.
New Castle—Melvin, Russell C.
New Kensington—Fletcher, B. J.
*Straub, F. J.
Norristown—Long, James B.
Northampton — Moyer, Wm. N.
Northmont - Reading — Berks Building Block Co. (G. M. Muth, Treas. & Mgr.)
Palmerton—New Jersey Zinc Co.
Penn Valley — Corridon, J. B.
Philadelphia—Baily, R. W.
Ballinger Co., The (Jean Paul Rickter)
Baylson, J. Jacob
Berry, H. C.
Bowman, H. L.
Brennan, Frank X.
Brown, Paul G.
Bruner, Louis S.
Campion, H. T.
Cassell, J. D.
Coffman, Herbert
Concrete Protection & Color Co. (John McKay)
Conwell & Co., E. L. (E. L. Conwell, Pres.)
Cooper, W. R.
Covell Corp., The
Delaplaine, Henry
Drehmann Paving Constr. Co. (C. E. Drehmann)
Formigli Architectural Stone Co. (Paul Formigli, Sec.)
Foster, Jr., Alexander
Gaston, H. F.
*Giant Portland Cement Co. (Chas. F. Conn, Pres.)
Gibson, W. Herbert
Glasheen, R. E.
Gravell, Inc., Wm. H. (Wm. H. Gravell, Pres.
Hallahan, John P.
Hebold, Denis O.
Hibbs, Manton E.
Hilts, H. E.
Hipwell, Howard S.
Horst Co., Henry W. (A. E. Horst)
Johnson, Virgil L.
Knopel, Herbert J.
Lamb Co., Robert E. (Robert E. Lamb)
Lesley, Robert W.
Lindsay & Co., Inc., W. W. (James C. Newlin, V. P.)
*Lone Star Cement Co. (H. E. Hilts)
Louchheim, Wm. S.
McComas, Wm. E.
Mauro, Francesco
Mueller, Harold P.
*National Building Units Corp.
Nelson Pedley Construction Co. (Joseph Milgram)
Peiper, A. S.
Perrot, Emile G.
Power & Son, Eugene S. (E. S. Power)
Reynvaan, A. J.
Ridge, R. S.
Riehle Bros. Testing Machine Co. (W. C. Moran)
Rogers Co., J. S. (J. Clyde Rogers)
Roth, Jr., Charles Oliver
Sauter, Wm. R.
Seward, Harold C.
Schautz, C. Paul
Sinclair & Grigg (Harris Britt)
*Steele & Sons Co., Wm.
Steele & Sons Co., Wm.
Stevens, Charles H.
Stewart, Frank G.
Tatnall, Francis G.
Thompson, Carroll R.
Thorn, Jr., Frederick G.
Timlin, M. A.
*Turner Construction Co. (J. A. Turner)
Uhr, Saul

*United Engineers & Constructors Inc. (Prof. F. O. Dufour)
Van Asdlen Construction Co. (W. S. Van Asdlen)
Wagner, Samuel T.
Warner Company
Warren Company, F. V. (Lewis Tower)
Watson, T. P.
Webb, Walter Loring
White & Co., Barclay (Barclay White)
*Whitehall Cement Mfg. Co. (P. D. Gaskill)
Williams, Timothy S.
Wilson, A. R.
Winslow Construction Co. (John S. Krauss)
Witmer, Francis P.
Woodle, Jr., A. S.
Wyatt, W. Kirk
Pittsburgh — Aluminum Company of America (James W. Rickey)
American Reduction Co. (Jay Moore)
Anderegg, F. O.
Benedict, E. L.
*Blaw-Knox Co.
Burgess, C. C.
Burke, J. E.
Burks, I. E.
Campbell, John T.
Casey Co., John F. (Samuel Leslie Fuller)
Concrete Products Co. of America (C. F. Buente)
Connar, V. N.
Dann, Alex W.
Dibert, Grant
Dunnells, Clifford G.
Duquesne Slag Products Co. (C. L. McKenzie)
Freeman P. J.
General Cement Products Co. (R. D. Campbell)
Haggert, C. N.
Hayner, J. L.
Imlay, R. G.
Jones & Laughlin Steel Corp. (J. B. Carlock)
Kaiser, B. J.
Kubitz, Fred
Lambie, Joseph S.
Larkin, Chas. W.
Levison, Arthur A.
McCullough, Frank M .
Metzger - Richardson Co. (F. L. Metzger)
Meyer, B. F.
Mylrea, T. D.
National Steel Fabric Co. (W. H. Shaffer, Jr.)
Norris, W. H.
Pittsburgh, City of (Winters Haydock)
Pittsburgh Testing Laboratory (A. R. Ellis, Gen. Mgr.)
Plagwit, Eric
Prack, Bernard H.
Price, Philip W.
*Rust, H. B.
Saurbrey, Alexis H.
Standard Inspection Co. (John M. Bailey)
Stotz, Jr., Edward
Vegeler, W. F.
Western Pennsylvania Sand & Gravel Assn. (Ray V. Warren)
Westinghouse Electric Mfg. Co. (J. E. Webster)
Westinghouse Electric & Mfg. Co. (Dr. H. C. Harrison)
Wilcox, Inc., Ira C. (Jno. Rishel)
Wimer, D. C.
Wiseman, W. J.
Pottsville — Pottsville Building Block Co. (Barton R. Biever)
Reading—Hoffman, A. E.
Muhlenberg, Charles R.
Roxborough — Flanagan, Charles A.
Safe Harbor—Robb, Chas. G.
Scranton—Baker, Samuel
Smoley, Constantine K.
Sharon—Bishop, Howard
State College—Minshall, R. E.
Swarthmore—Lilly, Scott B.
Swissvale—Abel, Norman A.
Upper Darby — Artcrete Products Co. (Clarence E. Kuemmerle)
West Manayunk—Painter, Geo. M.
Wilkes-Barre — Luzerne County Road & Bridge Dept. (Robert L. Williams)
Rosser, Robert C.
Wilkinsburg—Frick, Walter H.
Hoffman Co., F. (Wm. F. Hoffman)
Williamsport — Williams, E. C.
Wilmerding — Livermore, A. D.

Rhode Island

Cranston—Steimer, William A.
Pawtucket — Builders Concrete Stone Co. (Fred D. Fuller)
Providence—Ballou, Henry W.
Benson, Newton D.
Corrado, Anthony
Holton, Jr., Philip J.
Maguire Co., Chas. B.
Merchant, Archie W.
Nolan, S. Frank
Providence Transit Concrete Corp.
R. I. State Bd. of Public Roads (J. V. Keily)
Sheldon & Son, F. P.
Swanson, Inc., G. Fred (G. Fred Swanson, Pres. & Treas.)
Watt, Edwin L.
Shawomet—Bragger, E. Y.

South Carolina

Anderson—Guest, Walter C.
Columbia—South Carolina State Highway Dept. (N. S. Anderson, Maint. Engr.)
South Carolina Highway Dept. (W. H. Mills, Jr., Test. Engr.)
Beaufort, Sea Islands—Gleason, Kate

South Dakota

Canton—Canton Block & Tile Co. (E. D. Rowe)
Rapid City—South Dakota Cement Plant (William Fowden, Supt.)
Vermillion—Pietta, Dan H.
Watertown — South Dakota Concrete Products Co. (Hugh H. Johnson, Mgr.)

Tennessee

Alcoa—Nowlin, Wm. D.
Chattanooga—Klein, W. H.
Pennsylvania-Dixie Cement Corp. (E. P. Newhard)
*Signal Mountain Portland Cement Co. (John L. Senior, Pres.)
Smallwood, L. C.
Cowan—Ernst, Walter S.
Fountain City—Nielsen, S. W.
Jackson—Yandell & Conger (C. H. Yandell)
Johnson City—Brekke, G. N.
Knoxville — McCroskey, Thos.
Ready Mixed Concrete Co., John L. Humberd, Pres.)
Southern Cement Products Co. (Fred W. Weigel)
Lebanon—Gentry, J. W.
Memphis—Allen, Thos. H.
Busse, F. A.
Hollywood Concrete Pipe Co. (O. H. Miller, Pres.)
Howe, H. N.
Hunter, Harry B.
Loeb, II, Henry
Nichols, C. R.
Schevenell, V. E.
Sullivan, F. Daly
Nashville—Bauman, E. W.
Burr, Henry A.
Coolidge, W. A.
Franklin Limestone Co. (A. B. Rodes)
Gould Contracting Co. (C. B. Wilson)
Hansard, Orren H.
Hopton, H. V.
Nashville Breeko Block & Tile Co. (Chas. Wm. Akers, Mgr.)
Norred, Jr., C. V.
Rowan, Wm. H.
Wilson-Weesner-Wilkinson Co. (W. C. Sensing)
Richard City—Shuman, E. C.

Texas

Austin — Ferguson, Phil. M.
Giesecke & Harris (Munsey Wilson)
University of Texas, Dept. of Civil Engineering (Dean T. U. Taylor)
University of Texas, Engineering Experiment Station (Raymond F. Dawson)
Wright, Chester C.

Brownwood—Keesee, Gerald B.
Bryan—Butler, R. B.
College Station — Texas Engineering Experiment Station (F. E. Giesecke, Director)
Richey, Prof. J. J.
Dallas—Browne, E. F.
Clapper, Lyle
Clark, Charles A.
Ferguson, Lewis R.
Gill, Grayson
Jameson, R. O.
Knox, Jean H.
*Lone Star Cement Co. (L. R. Ferguson)
Nash, Jack T.
Penniman Concrete & Material Co. (Nolan Browne, V. P.
Reaney, Charles F.
Simpson, C. F.
Watson Company (G. W Andersen)
El Paso—Anderson Bros. (W. R. Anderson)
Deedy, Walter E.
McKee, Robert E.
Southwestern Portland Cement Co. (Wm. R. Blair)
Trost, A. G.
Fort Worth—Byrne, Thos. S.
Gillette, Harold S.
Southwestern Laboratories, (F. B. Porter, Pres.)
Freeport—Burns, Homer S.
Rhodes, J. Morton
Galveston —Fraser, Andrew
Houston — Calhoun, Jr., John C.
Houston. City of (H. L. Show, City Engr.)
Dannenbaum, J. B.
Fugate, G. L.
Gottlieb, R. D.
Gulf Concrete Pipe Co. (H. E. Johnsen, Vice-Pres.)
McKenzie, J. G.
Weismann, George F.
Laredo—Zachry, H. B.
Lubbock—Haynes, S. B.
Peters, Strange & Bradshaw (N. L. Peters)
Texas Technological College (J. H. Murdough)
New Braunfels—Dittlinger Lime Co. (E. Eikel)
Pharr—Devine, P. S.
San Antonio — Beretta Engineers, Inc., J. W. (J. W. Beretta, Pres.)
Diver, M. L.
*San Antonio Portland Cement Co. (C. Baumberger, Pres.)
Simpson Co., W. E. (W. E. Simpson)
Southern Cement Products Co. (Harvey Perrin)
Victoria—Killian, M. B.
Waco—Central Texas Iron Works (L. H. Wood)
Johnson, O. K.

Vermont

Bennington—Burrington, Jr., M. J.

Virginia

Blacksburg—Begg, R. B. H.
Bristol—Stone, G. M. & G. C.
Clarendon — Mitchell, Nolan D.
Henry—Blue Ridge Talc Co., Inc. (C. O. Kitson. Secy.-Treas.)
Hopewell—Rowland, Walter
Norfolk—*Lone Star Cement Co. Va., Inc. (Dwight Morgan)
Onley—Norfolk, Parker F.
Richmond — Economy Concrete Co. of Va., Inc. (Ernest Wiedemann)
Froehling & Robertson (T. B. Hartless)
Lee, Smith & Van Dervoort, (Jameson Van Dervoort)
Macatee, W. R.
Thurston Co., Inc., W. P. (W. P. Thurston)
Riverton—Riverton Lime Co. (G. H. Hutchinson)
Roanoke—Ferguson, M. W.
South Washington — Davis, Herbert A.

Washington

Bellingham — Olympic Portland Cement Co. Ltd., The (A.F. Krabbe, Gen. Supt.)
Bremerton—Jack, Eugene C.
Morreell. Ben
Concrete—Superior Portland Cement Co. (C. L. Wagner)
Everett—Everett Concrete Products Co. (Hans Mumm, Jr.)
Olympia — Washington State Highway Dept. (Bailey Tremper)
Williams, Chas. H.
Port Angeles — Owen, Thos. W.
Puget Sound—Cotter, Lt. Comdr. C. H.
Seattle—Boyle, Ernest E.
Bushnell, H. L.
Cavanagh, Jr., W. Curran
Collier, Ira L.
Faulkner, H. F.
Gleason, W. A.
Hadley, H. M.
Hitchings, A.
Hull, Herbert F.
Hunt, Thomas D.
Hutton, S. E.
Lincoln, R. W.
More, Chas. C.
Northwest Concrete Products Assn. (F. R. Zaugg)
Northwest Steel Rolling Mills, Inc. (Paul H. Steuding, Sales Mgr.)
Ober, R. H.
Olympian Stone Co. (Leo Swartz)
*Olympic Portland Cement Co. (W. P. Cameron)
Pacific Coast Cement Co. (Ned H. Nelson)
Pacific Coast Steel Corp. (W. A. Roth)
Pacific Stone Co., The (Gilbert E. Tucker)
Perry, L. A.
Pioneer Sand & Gravel Co. (Phillip Morrison)
Seattle, City of
Seattle, City Engineer's Dept.
Sheffield, F. D.
Stevenson, J. H.
Strandberg, E. L.
Suckow, V. C.
*Superior Portland Cement Co. (E. P. Lucas)
Sylliaasen, M. O.
Trueblood, Paul M.
Uhrich, M. J.
Vaso Manufacturing Co. (Carl L. Leon, Mgr.)
Ward, Inc., J. F. (J. F. Ward)
Way, W. F.
West, J. R.
Winston Bros. Co. (W. H. Gardiner)
Witte, Herman Calvert
Tacoma—McKay, W. S.
Smallwood, H. S.
Yakima—Yakima Cement Products Co. (W. P. Hews)

West Virginia

Alderson—McThenia, A. W.
Huntington — Schonthal, D. C.
Martinsburg—Young, W. J.
Morgantown—Brooks, W. E.
Davis, Fred A.
Wheeling—Faris, Frederic

Wisconsin

Appleton—Koepke Bros. Construction Co. (G. A. Koepke)
Fond du Lac—Hutter Construction Co. (George F. Hutter)
Immel Construction Co. (Harry W. Mabie, Jr.)
Johnson, Robert C.
Kenosha — North Shore Cement Burial Vault Co. (Hubert McQuestion)
Madison—Blue Jay Concrete Products Co. (Chas. Clare)
Fritz Co., C. B. (N. J. Schmitz)
Larson, Guy H.
Madison Silo Co. (C. C. Woody)
Wisconsin University Library (W. M. Smith)
Withey, Morton O.
Manitowoc — Manitowoc Portland Cement Co.
*Manitowoc Portland Cement Co. (E. J. Maguire, Vice-Pres. & Treas.

Milwaukee — Browne, Walter E.
Burmeister, R. A.
*Chain Belt Co. (B. F. Devine)
Christoffel Art Stone Co. (John Christoffel)
Cincrete Corp. (L. E. Pitner)
Clicquennoi, I. M.
Coddington Engrg. Corp. (Samuel C. Coddington)
Consumers Supply (S. N. Brown)
Devos Co., Inc., Wm. H. (A. W. Devos)
Eagle Chemical Co. (Chas. Schrank)
Foster Construction Co., The (Harry L. Foster)
Franklin, Jack
Froemming Brothers Inc., (B. A. Froemming)
Hahn, Harold S.
Harris, Wallace R.
Hirschberg, Walter P.
Hirth Concrete Breaking Co. (G. W. Hirth)
*Koehring Company, The
*Koehring Company, The (E. H. Lichtenberg)
Kolinski, M. C.
Larson, Louis J.
McKown, G. W.
Milwaukee Concrete Products Cooperative Assoc.
*National Equipment Corp., The
Peterson, Lawrence E.
Ricketson Mineral Color Works (Frederick C. Bogk, Pres.)
Riesen's Sons Co., Paul (Louis F. Reuter, Jr.
Rose, T. L.
Schmitt & Son, Inc., H. (Eugene H. Schmitt)
Siesel Co., S. M. (S. M. Siesel, Pres.)
Simmond, Fred C.
Stanage, John L.
Talbot, Kenneth H.
Tubesing, William F.
Whitney, Chas. S.
Wiepking, C. A.
Oshkosh — Badger Concrete Co. (E. Olsen)
Larsen-Morgan Co. (R. W. Morgan)
Prairie Du Chien—Prairie Concrete Products Co. (G. A. Kahler)
Racine—Julius Sorenson & Sons
Sheboygan — Donohue, Jerry
Superior—Buck, R. C.
Waukesha — Butler Bin Co. (Morgan R. Butler, Pres.)
Wausau — Wausau Concrete Co. (C. W. Parsons, Pres.)

Alaska

Juneau—Krause, G. E.

Canal Zone

Ancon—Bunker, Geo. C.
Balboa Heights—Hertz, A. L.
Jones, R. C.
Moore, L. B.
Randolph, Edward Sydney

Panama

Panama City — Arango, Henrique G.
Hidalgo, Rafael A.
Puerto Armuelles — Millen, Vincent

Hawaiian Islands

Hilo—Will, Charles H.
Honolulu—Bishop Estate, B. P. (Theo. B. Bush)
Hawaiian Contracting Co. (H. P. Benson)
Miller, G. R.
Morgan, J. Grant
Robert, E. E.
Pearl Harbor—Manning, J. J.

Philippine Islands

Manila—Siochi, Pedro
Licuanan, Jose G.

Porto Rico

Guayama—Lucchetti, A.
Mayaguez—College of Engineering (Frank O. Kerr)
Moto, Candelario Calor
San Juan—Benitez & Benitez Gautier
Gonzalez, Adriano
Dept. of the Interior (Commissioner Guillermo Esteves)
Totti, Etienne
Santurce—Gonzalez, Carl E.

Canada

Alberta

Calgary—Bennett, John G.
Lain, John Sayers-Neil, J. S.

British Columbia

Vancouver—Barclay, J. B.
British Columbia Electric Ry. Co. Ltd. (E. E. Carpenter)
Brown, Philip P.
Grant, J. R.
Hamilton, Chas. T.
Mackney, A. E.
Marble, William O.
Northern Construction Co. Ltd. (Wm. Smaill)
Victoria—*British Columbia Cement Co., Ltd. (Edwin Tomlin, Director-Treas.)

Manitoba

Brandon — Fulcher, Edmund
Winnipeg—Cowin & Co. Ltd. (H. B. Henderson)
Greater Winnipeg Water District (W. M. Scott)
Library, Univ. of Manitoba
National Testing Laboratories, Ltd., The (L. J. Street)
Peterson, F.
Rensaa, E. M.

New Brunswick

Saint John—Evans, Edwin Ronald
Johnston, W. J.
McKinney, J. Harold

Nova Scotia

Halifax—Sexton, F. H.
Noonan, W. H.
Nova Scotia Power Commission, The (Harold S. Johnston)

Ontario

Campbellford — Burgar, F. A.
Cochrane—McCarthy, T. V.
Fitzroy Harbor—Mackie, Thos. W.
Morrow & Beatty Ltd. (J. A. Beatty, V. P.)
Ford—Merlo, Merlo & Ray, Ltd. (Louis Alvin Merlo, Pres.)
Hamilton—Brown, John A. W.
Canada Crushed Stone Corp. (C. M. Doolittle)
Darling, E. H.
Johns, H. S.
Piggott, Joseph M.
Kemptville — Dominion Concrete Co., Ltd., The (W. G. Anderson)
Dominion Concrete Co., Ltd., The (W. G. Anderson, Pres.)
Ottawa — Canadian Engineering Standards Assn. (B. Stuart McKenzie, Sec.)
Canadian National Parks Branch (J. B. Harkin)
Hayley, Harry
Lucas, J. W.
Ottawa Suburban Roads Commission (Alan K. Hay)
Viens, E.
Peterboro—Hanna, H. B.
Port Arthur—Howe, C. D.
Sandwich — Thompson, R. M.
Thorold—West, C. W.
Toronto—Adamson, R.
Babcock, H. A.
Ballentine, W. L.
Billings, A. W. K.
Chapman & Oxley (J. Morrow Oxley)
Cote, A. U.
Engholm, F. G.
Goss, R. G.
Gray Construction Co., Ltd., J. V. (Mr. Milligan)
Harkness, London & Hertzberg
Holmes, Ltd., A. R. (A. R. Holmes, Pres.)
Hurlburt, R. W.
Hydro-Electric Power Com.
Hynes, Ltd., W. J. (W. S. P. Hannaford)
James, Proctor & Redfern, Ltd., (W. D. Proctor)
Lavelle, J.
Jackson-Lewis Co., The (C. Blake Jackson)
Martin, Evan S.
Moran, Robert L.

Peerless Stone Ltd. (F. E. Beer)
Sagar, W. L.
Schnarr, Wilfrid
Standard Paving & Materials Ltd. (G. G. Robinson)
Stewart, G. M.
Super Cement (America) Co., Ltd. (E. W. Reed-Lewis)
Tinkler, J. W.
Toronto Ready Mix Concrete Ltd. (C. E. Reynolds)
Raalte, S. Van
Wallace, Gordon L.
Weatherbee, L. B.
Wilshaw, P.
Young, Clarence R.
Young, R. B.
Walkerville — Trussed Concrete Steel Co., of Canada, Ltd. (E. G. Ryley, Chief Engr.)
Welland—Scott, J. R.
Woodstock—Independent Concrete Pipe Co., Ltd., (James Carnwath)

Quebec

Arvida—Alcoa Power Co., Ltd. (C. P. Dunn, Ch. Engr.)
Beauharnois—Angers, A.
Cothran, F. H.
Gauthier, P. G.
Miller, N.
Chicoutimi—Caffiaux & Villeneuve (P. A. Villeneuve)
Lavoie & Deslisle
Kenogami—Fenton, P. M.
Tappan, K. H.
Wood, David B.
Montreal — Aerocrete Corp. of Canada Ltd. (W. F. Drysdale)
Blanchard, J. E.
Brett, John F.
Burge, A. W.
Carmel, Jos. Ed.
*Canada Cement Co., Ltd. (H. S. Van Scoyoc)
Canadian National Railways (W. A. Duff)
Consolidated Pipe Co. Ltd. (E. A. Sherrard)
Cook, W. A.
Cormier, Ernest
Duntile Co. Ltd. (R. McGillivray)
Ecole Polytechnique
Foundation Co. of Canada Ltd., The (V. G. Younghusband)
Gibbs, F. H.
Milton Hersey Co., Ltd. (M. F. MacNaughton)
Hunt & Co. Ltd., Robert W. (F. O. Farey)
Lalonde, Jean Paul
Lea, William S.
McCurdy, L. B.
McGill University Library (G. E. Lomer, Librn.)
Morssen, C. M.
Raymond, Charles
Robertson, R. K.
Smallhorn, E. R.
Surveyer, Arthur
Van Scoyoc, H. S.
Vincent, R. A.
Warnock & Co. Ltd., Chas. (Chas. Warnock)
Quebec—Fraser, Alexander
Langlais, Zachee
Quebec, City of (Edouard Hamel, Ch. Engr.)
Quebec Dept. Pub. Wks. & Labor (Ivan E. Vallee)
Quebec Dept. of Roads (J. L. Boulanger)
Rapide Blanc—Durham, G. D.
Paquette, J. E.
St. Johns—Standard Clay Products Ltd. (C. T. Trotter)
Westmount—Gardner, W. McG.

Saskatchewan

Regina — Concrete Products Ltd.
Saskatoon—Martin, F. J.
Thorvaldson, T.
Williams, G. M.

Argentina

Buenos Aires — Arenas, Eduardo
Balina, M. R.
Barberis, Alejandro A.
Bond, Guillermo
Gottschalk, Otto
Gutierrez-Salinas, Jorge B.
Hume, Albert S.
Schnack, Benno J.
Sobral, Arturo B.
Valle, Juan Agustin
Cordoba—Cisneros, Raul
La Plata — Fernandez, Juan M.
Grisi, Adolfo P.
Palazzo, P.

Australia

Adelaide—James, W. H.
Bendigo—Flight, Oscar
Power S. M.
Brisbane — Campbell & Sons, Ltd. James (J. L. Bell)
Eklund, H.
McWilliam, R. J.
Mortley, H. R.
Queensland Main Roads Comm. (J. E. England)
Reinhold, W. J.
Twine, G. J.
Cairns—Hill & Taylor
Charbon—Saville, Christopher James
Geelong—Australian Cement, Ltd. (W. B. McCann, Gen. Mgr.)
Hawthorne — Nonporite Pty. Ltd. (Norman Griffith)
Ipswich—Haenke, Martin William
Leeton—Hislop, W. A.
Maryborough — Jorss, Chris A.
Melbourne — Concrete Construction Pty. Ltd. (L. A. Deegan)
Eldridge, R. V. F.
Hume, Walter Reginald
Overend, A. B.
Tayor & Co., Richard (Frank J. Hannan)
Sutherland, John D.
Wood, J. V.
Newcastle — Broken Hill Proprietary Co., Ltd. (L. Bradford, Mgr.)
Rooty Hill—Watts, Ivo S.
Sydney—Bailey, G. S.
Bedford, Max E.
Commonwealth Portland Cement Co. (Fred J. Beardmore, Secy.)
Concrete Constructions, Ltd. (Thorpe Bray)
Daw, E. A. H.
England, John
Everingham, E. C.
Garnsey, Arnold Hugh
Hinder, R. B.
Hoskins, C. H.
Kneeshaw, F. P.
Macdonald, A. S.
Main Roads Board of N. S. W. (T. H. Upton)
McLean, William King
Rankin, John
Standards Association of Australia (W. R. Hebblewhite)
Stanley, M. S.
Townsville—Hunt, W.
Woollahra—H. G. Verey

Belgium

Antwerp—Cimentaries Et Briquetaries Reunies C. B. R. (F. Van Ortroy, Secy.)
Brussells — Groupement Prof. des Fabricants de Cement Portland Artificial de Belgium (G. Deroover)
Le Solidit it Belge (I. Molle)
Liege—Franki, Pieux

Brazil

Campos—Vieira, E. de Moraes
Rio de Janeiro — Baumann, Alfred
Baumann, Herman
Broe, Harald
Carvalho, Manfredo de A.
Curtis, J. P.
Dodsworth, E.
Harboe, Helge
Moorby, J. Howard
Passos, Edison J.
Reis, F. Santos
Seibert, Charles Jay
Sao Paulo—Alvares, Jr., J. C.
Alves de Lima, Jorge
Fonseca, Humberto da
Filho, Julio Miguel Freitas
Heilbronner, L. C.
Severo & Villares
Telles, Francisco T. da Silva
Torres, Ary F.
Urner, J. P.

Br. North Borneo

Sandakan—Bishop, Harry

Chile

Santiago — Alessandri, Carlos
Valparaiso — Claussen, Carlos F.
Vina del Mar—Feuereisen, Eduardo H.

China

Canton—Bjuke, Capt. N. Rob
Dairen — Onodo Cement Co. Ltd. (K. Mizoguchi)
Mukden—Kao, P. K.
Shanghai—Lee, Kung Wu, Pond S.
Tangshan — Chiao Tung University, Library
Li, Shu-t'ien
Tientsin — Hayes Engineering Corp., J. E.
Pei Yang University
Yu, M. T.

Cuba

Havana—Cristofol, J.
Fitz Gerald, C. C.
Martin, Juan San
Martinez, Jose Ricardo
Rodrigvez, Lvis M.
Vila, Jose Antonio
Santiago—Formell, Victor M.
O'Fallon, R. S.

Czechoslovakia

Bratislava—Franc, Joseph

Denmark

Copenhagen — Christiani & Nielsen
"Danalith" A/S,
Teknisk Bibliotek (Helge Holst)

Egypt

Alexandrie — Gazaleh, Edouard
Beni-Suef—Wassef, K. Zaki

England

Bristol — Robertson, Andrew
East Molesey — Smith, Major N. H.
Garston—Glanville, W. H.
Stradling, R. E.
Halewood—Burgess, L. T.
Harrogate—Button, Harold
Ness, Gilbert
Haverton Hill—Kimpton, A. C.
Hull—Earle, Ltd., G. & T. (G. F. Earle, Mgr. Dir.)
Ipswich—Tetsall, E. P.
Leeds—Airey, Sir Edwin
Leicester—Ellis & Sons, Ltd., John (Basil C. Sharman)
Liverpool—Bates, Henry K.
London—Ames, John
Associated Portland Cement Mfrs., Ltd., (H. R. Cox)
Barron, S. N.
Brabant, Harry M.
Butler, D. B.
Cast Concrete Products Assn. Ltd., The (A. S. Windsor)
Empire Stone Co., Ltd.
Garrett, W. S.
Hambley, Percy Noel
Mouritz, C.
Osler, Richard H.
Props of Hay's Wharf Ltd., (H. J. M. Skidmore)
Riley, Harbord & Law (E. W. Palmer)
Smith, R. A. B.
Stanger. R. H. Harry
Stewart, Wm. J.
Stuart's Granolithic Co. Ltd. (Wm. Adams, Mgr. Director)
Wallace, W. K.
Manchester — Bentham Cecil
Bridges, G. P.
Singleton-Green, J.
Stokes, G. W.
Plymouth—Blake, F.
Rugby—Blyth, Charles E.
Brooks, Ernest W.
Kaye, Lister Lister
Scunthorpe — Hydroprest Products Co. (A. Ogilvie)
Sheffield—Turner, Frank C.
Stockport — Mercer, L. Boyd
Wednesbury—Wilson, N. W.
Wolverhapmton — Cotterell, Ernest L.
Yorks—Marsden, R. W.

Finland

Helsingfors — Cement-producenternas (Urho Aberg)
Osakeyhtio Constructor Aktiebolag
Pargas—Pargas Kalkbergs Aktiebolag
Vaasa—Waasan Rautabetoni O. Y. (A. Lepisto)

France

Grasse—Magny, A. V.
Le Teil — Ste. Amedes Chaux et Ciments de Lafarge et du Teil (M. Rengade)
Paris—Hendrickx, Jean
Societe Des Ciments Francais (F. Turquais)
Soliditit Francais, Le

Germany

Berlin—Burchartz, H.
Haegermann, Dr.
Klank, Willy
Cologne—Stierlen, Wilhelm
Weerdt, H. E. de
Darmstadt — Kleinlogel, Prof. Adolf
Dusseldorf—Grun, Richard
Hover—Verein Deutscher Portland-Cement-Fabrikanten (Dr. Rudolf Kneisel)
Karlsruhe — Probst, Dr. Emil
Obercassel — Huser, Dr. Ing. Alfred
Oppeln—Simon, Dr. Nikolaus
Stuttgart — Graf, Prof. Otto

Holland

Amsterdam — Dekker, F. W.
De Steeg—Vigorose Cement Industrie, N. V. (B. A. Honig)
Delft—Technische Hoogeschool (J. A. Bakker)
The Hague—Dekker, P.
Ringers, J. A.

Honduras

La Ceiba—Suter, Oscar M.

India

Alwar City—Kohli, T. N.
Attock—Punjab Portland Cement, Ltd.
Barot—Sarwar, M. G.
Bengal—Nag, N. K.
Colaba—Baingolkar, H. V.
Bombay—Chhapgar, F. K.
Concrete Association of India (Alan Moncrieff)
Daruvala, J. P.
East, Frederick A. H.
Engineer, R. K.
Hartley, D. R. C.
Indian Hume Pipe Co. Ltd., The
Joglekar, M. V.
Kamat, V. A.
Master, R. S.
Noel-Paton, V. F.
Setna, J. N.
Calcutta—Choudhury, A. C.
Kynnersley, T. R. S.
Sanyal, A.
Delhi—Bose, N. N.
Israil, Mohammad
Siddique, Bashie Ahmad
Karachi — Bhaledino, Kambarali
Lakheri—Bundi Portland Cement, Ltd. (E. Christensen, Mgr.)
Christensen, E.
Larkana—Badlani, N. R.
Dunsdon, A. C.
Madras—Gray, T. Campbell
Meerut — Sharma, Hari Shankar
Mirpurkhas — Gazder, Mahamed Hashim
Mysore—Kikkeri, S. A.
Nasik—Thomas, A. Rylands

Ireland

Belfast—McIlmoyle, R. L.
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Italy

Bergamo—"Italcementi" (Carlo Vigliani)
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Cosenza—Steiner, Angelo
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Milano — Laboratorio Prove Materiali, Della R. Scuola Di Ingegneria (Giulio Revere)
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Roma—Associazione Italiana per gli Studi sui Materiali da Construzione (Camillo Guidi)
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Yamashita, Toshirow
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Tuz-Khurmatli—Lynam, C. G.

Mexico

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Ornelas, Samuel
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Gomez-Perez, Francisco
Howell, C. H.
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Puebla—Blank, Alton J.
Queretaro—Alvarez Hnos. Sucr. (Salvador Alvarez)

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Jeffrey, W. McKenzie
Murray, Andrew
Oxenham, S. S.
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Dannevirke—Gillon, Gerald Norton
Nelson—Jack, Erick D.
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Palmerston North — Wright, A. H. W.
Wanganui — Hodge, Ernest R.
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PROCEEDINGS OF THE AMERICAN CONCRETE INSTITUTE, VOLUME 27

In general, important subjects are classified and indexed under approximately 30 main headings each one appearing in its proper alphabetical order in bold face capital letters—as for instance, ARCHITECTURAL DESIGN. "Surface treatment" and other subjects classified under this head, are indented.

Key words to important subjects appear, in alphabetical order in addition to the general classification—as for instance "Admixtures" and "Blast furnace slag," each referring to MATERIALS AND TESTS under which all allied references appear, indented. Authors' names appear in proper alphabetical sequence with the subjects, with references to their contributions.

Specific data on Beams are so indexed by reference to "ENGINEERING DESIGN" or "TESTS OF MEMBERS AND COMPLETED STRUCTURES" thus avoiding an oversight by the searcher of important allied data.

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ERRATA—ABSTRACTS

Nomogram for calculating allowable distance between abutments of vertical or inclined reinforced concrete slabs as determined by diagonal tension and shear.

P. 146, lines 26-32 should be as stated in the author's correction, p. 304, lines 30-36.

Experiences from a power plant construction in India, p. 180, line 29, *The Swedish contracting company "Vatten byggnadsbyran"* should be *The Swedish consulting engineers Vattenbyggnadsbyran.* The contractors of the civil engineering work at the power station were Messrs. Topham, Jones and Railton of London.